

Mu'tah University

Deanship of the Graduate Studies

Computer Aided Workplace Design and Management

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DEDICATION

To the memory of my father, and to my mother, brothers, and sister (Sinan, Siraj, Suhaib, Aws ,Tasnem)

Sema`a M. Al-Oran

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I wish to express my sincere gratitude and appreciation to my supervisor, Professor Salloum A. Al-Jibury, for his assistance, constructive suggestions, generous advice, guidance and continuous encouragement.

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Abbreviations

Symbols	Definition
OSHA	Occupational Safety And Health Administration
CTP	Computer To Plate
WC	Water Cycle
CAD	Computer Aided Design
2D	Two Diminutions
PPE	Personal Protective Equipment
m^2	Meter
˚C	Celsius Degree
FE	Fine Extinguisher
LEV	Local Exhaust Ventilation

ABSTRACT

Computer Aided Workplace Design and Management

Sema`a M, AL-Oran

Mu'tah University, 2012

The present study was conducted to analyze and study workplace layout and elements for two selected sites. The first site was selected at Mu`tah University and the second site was at Ad-Dustour newspaper industry.

The study was conducted according to the methodology that includes literature review, site visit, assessment, and description of the existing conditions and layout at the two sites, modeling and simulation study using AutoCAD 2007 and PROMODEL.

This work describes a workplace in the two cases of the study which both have many considerable defects in the design compared to the international standards, at the two sites. The workplaces were found unsuitable in terms of number of elements.

The results showed that there are considerable defects in the workplace suitability with the standards and productivity, and then redesign these two cases of study to improve the workplace to give an optimum output either for employee or time consumption for production, health and environment. The study recommended number of enhancements in order to increase efficiency and productivity. The study also showed the redesign workplaces for the two cases of study. There are big differences between the present workplaces and the redesign workplaces, sometime reached up to 100% in some elements that reflected on employee performance, time duration to do their work, the health of workers and the environment of the workplace, quality and the productivity in general.

الملخص

الإدارة وتصميم مكان العمل باستخدام البرامج المدعومة بالحاسوب

سيماء مفضي العوران

جامعة مؤتة ، 2012

التصميم أو الترتيب الداخلي للمصنع هي الكيفية التي يتم بموجبها تحديد الموقع النسبي لكل ماكينة أو مجموعة من الماكينات، وترتيب محطات العمل داخل الأقسام الإنتاجية، ووضع الماكينات والمعدات بشكل يضمن تتابع العمليات الإنتاجية، وسهولة حركة وتدفق المواد الخام على خطوط الإنتاج، بحيث تكون محصلة ذلك أداء العملية التصنيعية بكفاءة عالية ويعتبر من مجالات البحث في الإدارة الهندسية من اجل تحقيق أعلى كفاءة إنتاجية ممكنة، وذلك من خلال تخفيض الوقت اللازم لعمليات النقل والمناولة وتحرُّك العاملين وتنقلهم داخل المصنع. وكلما قل الوقت المطلوب لعملية الإنتاج كلما أدى ذلك إلى تخفيض تكلفة الوحدة الواحدة المنتجة، وكلما انعكس ذلك بالتالي على زيادة معدل الإنتاجية في المصنع. كما أن الاستغلال الأمثل للمساحة المتاحة في المصنع، يقلل من تكاليف الإنتاج.

وتهدف الدراسة إلى تحليل وتقييم أماكن العمل ومناسبتها للعاملين حيث تمت دراسة العناصر المتعلقة بمكان العمل وتأثيرها على العامل والإنتاجية ومقارنتها بالمعايير العالمية بأخذ موقعين للدراسة: الأول المشاغل الهندسية في جامعة مؤتة وثانياً: مطابع الدستور. تمّ في هذه الدراسة باستخدام البرامج المحوسبة توضيح أهمية هذه البرامج والدور الذي تلعبه في دعم الإنتاج والإدارة بشكل عام داخل مكان العمل.

ولتحقيق هدف الدراسة فقد اعتمد البحث على المنهج التحليلي والدراسات السابقة والزيارات الميدانية للحالتين الدراسيتين كمنهجية بحث.

تم انجاز الدراسة بوضع تصميمات مقترحة تحقق الفاعلية والإنتاجية للمقارنة بين أماكن العمل الموجودة حالياً وقد تبين مدى عدم جاهزية أماكن العمل الحالية وتتضمن الدراسة جملة من النتائج من أهمها وجود فروقات بين مقاييس مكان العمل الحالية والمعايير العالمية بنسب تجاوز بعض الأحيان بنسبة 100%.

إنّ التصاميم المقترحة في الدراسة الحالية ترفع من الإنتاجية والفاعلية والمرونة وتحقق سلامة العاملين، وتبين الدور الذي تساهم به الإدارة الهندسية وتطبيقاتها في رفع الكفاءة للعمل والعمال وفي النهاية تحسين الإنتاجية.

Chapter One
Introduction

1.1 Introduction

The industrial engineering can help the people, institutions and companies to produce things better, faster, safer, and save money, and stay competitive engineer to figure out how to do things better and engineer processes and systems that improve quality and productivity. Engineers make significant contributions to manufacturing companies by saving money, and at the same time, making the workplace better for fellow worker.

One of the important engineering activities is to analyze the job or workplace. This is to be used for quality and productivity improvement specially the workers activities, working space, materials, machines, fixtures, tools and other equipment in the production department.

In this highly competitive world, the desire and expectation for high – quality and reliable goods are growing on a daily basis. Consumers now have access to products of higher design, quality and functionality at lower prices than were previously possible. Productivity becomes the dominant issues in the market place where customers make their buying decisions based on product quality; sometimes they can even pay more for what they consider as a high quality product.

Productivity improvement is one of the core strategies towards manufacturing excellence and it is also necessary to achieve good financial and operational performance. It enhances customer satisfaction and reduces time and cost to develop, produces and deliver products and service. Productivity has a positive and significant relationship to performance for process utilization, process output, product costs, and work-in process inventory levels and on-time delivery. Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time.

One of the most important factors that should be taken into account is to achieve productivity improvement alongside with the safety of workplace design.
According to Riggs (1997), the overall objective of plant layout is to design a physical arrangement that most economically meets the required output quantity and quality.

Zundi (2000), reported that Plant layout ideally involves allocation of space and arrangement of equipment in such a manner to minimize overall operating area.

Referring to the different definitions, the researchers define workplace design as:

The intentional effort to plan, design, execute, redesign the allocation, arrangement, and flow of physical resource as people, material, equipment and machines, non-physical resource as available space and activities, and their integrated relationships, in the space available for an organization within and outside buildings over time to achieve maximum levels of effectiveness, in a sustainable and flexible manner. (Duffy 2004. Riggs, 1997).

Designing the workplace and creating workspace are not only a question of corporate identity or health and safety, nor it is only a question of calculations on costs and benefits on building and property. In fact layout design is the spinal cord that links, coordinates and organizes all organizational elements and resources. It is one of the chief means by which organizational aspirations can be achieved. Unfortunately, in Jordan, the awareness levels of organizations are very low.

Managements, in the field of layout design haven`t yet reached an effective satisfactory level. This might be due to number of reasons, but mainly because of the gap that often exists between the designer and the manager, or because layout responsibilities are handled by inappropriate parties, thus inadequate models of design prevail in these organizations hindering organization performance and effectiveness. It seems worthwhile to seek a better understanding of the concept of layout design and the primary factors that affect the choice of a specific layout and the relevant series of decision.

1.2 Background of the Study

This research will study and analysis the present workplaces and then redesign these workplaces to improve their elements. Two cases of study that have many considerable notes in the design, some could be easy to improve and the others based at the constructions of the building, the first case study is the workshop of Mu'tah University and the second is Ad-Dustour newspaper industry.

1.3 Problem Statement

Nowadays, many companies looking for improving their outputs and productivity to achieve their yearly target by eliminating some causes and production time that affect profit and get more safety degree. We are always hearing that the accident cases happened in manufacturing industries. The percentages of an accident in the manufacturing industries sector are always high compared to other sectors. The accidents are always happen because of poor or less care acting on Occupational Safety and Health (OSH) performances in some companies and because of the unsuitable workplace design.

In manufacturing companies, production floor workplace involves selection and arrangement of equipment such as machines used to manufacture products. Today, there are many methods exist to design, analyze and redesign the

production floor layout to improve productivity of a production line by using computer aided programs.

PROMODEL` s simulation is used to design and simulate whether the proposed new layout is efficient and possible to achieve the goal of the company (Roslin *et al*, 2008). By using simulation software, production line evaluation can be performed in a short time because model can solve the actual problems in the simulation software rather than rearranging the actual machine first before evaluation.

1.4 Factors Determining the Layout and Workplace Design Small business owners need to consider many operational factors in building or renovating a facility for maximum layout effectiveness. This criteria includes the following:

1. Ease of future expansion or change facilities should be designed and can be easily expanded or adjusted to meet changing production needs. Although redesigning a facility is a major, expensive undertaking not to be done lightly, there is always the possibility that a redesign will be necessary (Weiss and Gershon ,1989). Therefore, any design should be flexible. Flexible manufacturing systems most often are highly automated facilities having intermediate-volume production of a variety of products. Their goal is to minimize changeover or setup times for producing the different products while still achieving close to assembly line (single-product) production rates.
2. Flow of movement—The facility design should reflect a recognition of the importance of the smooth process flow. In the case of factory facilities, the editors of How to Run a Small Business state that "ideally, the plan will show the raw materials entering your plant at one end and the finished product emerging at the other. The flow need not to be a straight line. Parallel flows, U-shaped patterns, or even a zig-zag that ends up with the finished product back at the shipping and receiving bays can be functional. However, backtracking must be avoided in whatever pattern chosen. When parts and materials move against or across the overall flow, personnel and paperwork become confused, parts become lost, and the attainment of coordination becomes complicated."
3. Materials handling—Small business owners should notice that the facility layout makes it is possible to handle materials (products, equipment, containers, etc.) in an orderly, efficient and preferably simple manner.
4. Output needs—The facility should be laid out in a way that is conducive to help the business to meet its production needs.
5. Space utilization—This aspect of facility design includes everything from making sure that traffic lanes are wide enough so that inventory storage warehouses or rooms utilize as much vertical space as possible.

6. Shipping and receiving—The (Lasser, 1994). Institute counseled small business owners to leave ample room for this aspect of operations. "While space does tend to fill itself up, receiving and shipping rarely get enough space for the work to be done effectively," it said in How to Run a Small Business.
7. Ease of communication and support—Facilities should be laid out so that communication within various areas of the business and interactions with vendors and customers can be done in an easy and effective manner. Similarly, support areas should be stationed in areas that help them to serve operating areas.
8. Impact on employee morale and job satisfaction— Since countless studies have indicated that employee morale has a major impact on productivity, (Weiss and Gershon 1989) counsel owners and managers to heed this factor when pondering facility design alternatives: "Some ways layout design can increase morale are obvious, such as providing for light-colored walls, windows, and space. Other ways are less obvious and not directly related to the production process. Some examples are including a cafeteria or even a gymnasium in the facility design. Again, though, there are costs to be traded off. That is, does the increase in morale due to a cafeteria increase productivity to the extent that the increased productivity covers the cost of building and staff of the cafeteria.
9. Promotional value—If the business commonly receives visitors in form of customers, vendors, investors, etc., the small business owner may want to make sure that the facility layout is an attractive one that further burnishes the company's reputation. Design factors that can influence the degree of attractiveness of a facility include not only the design of the production area itself, but the impact that it has on, for instance, ease of fulfilling maintenance/cleaning tasks.
10. Safety—The facility layout should enable the business to effectively operate in accordance with Occupational Safety and Health Administration guidelines and other legal restrictions.

"Facility layout must be considered very carefully because we do not want to constantly redesign the facility," summarized (Weiss and Gershon, 1989). "Some of the goals in designing the facility are to ensure a minimum amount of materials handling, avoid bottlenecks, minimize machine interference, to ensure high employee morale and safety, and to ensure flexibility. Essentially, there are two distinct types of layout. Product layout is synonymous with assembly line and is oriented toward the products that are being made. Process layout is oriented around the processes that are used to make the products. Generally, product layout is applicable for high-volume repetitive operations, while process layout is applicable for low-volume custom-made goods."

1.5 Workplace and Management

Management science can help managers to solve a wide range of problems in the workplace and to make better decisions concerning the operation and strategy of the business. Management science offers managers many tools to help in analyze and interpret the data with which they are bombarded every day. Some of these tools include data mining, decision support systems, and forecasting techniques.

Workplace fatalities and injuries bring great losses to both individuals and societies. (Petersen, 2003) has reported that, people are the fundamental reason behind accidents and management is responsible for the prevention of accidents.
Jacobs, *et al.*, (1998) have pointed out that management failures represent the real and underlying cause of accidents; therefore goal setting and feedback Interventions should more adequately reflect and evaluate this management factors in their programs.

There are number of tools and techniques that can be used by managers to improve the effectiveness and efficiency of business operations. These include lean manufacturing, total quality management, and business process reengineering strives to improve the effectiveness and efficiency of the various processes within an organization.

Risk analysis and risk management work together to transform unacceptable risks into acceptable risks within a normal range. Different types of risks require different types of risk analysis and risk management tools. Such as risk-based, precaution-based, and discourse-based approaches. Once the risk analysis, evaluation, and risk classification are conducted, the proper risk management tool can be chosen and applied to the problem or situation (Klinke & Renn, 2002).
In addition, engineering management is used in the design and analysis of engineering experiments that are used to characterize, improve, qualify, and optimize the manufacturing processes as well as product performance and reliability.

The proper design of the appropriate workplace design allows engineers to draw valid conclusions from the quality, the workflow and other data collected.
Engineers use the technology specifically; this understanding can help in the development of better hypotheses that can be realistically tested using real world data. In addition, this understanding can help engineers to interpret the results of experiments and to apply them to the real world in order to continuously improve manufacturing processes.

1.6 Methodology

Two study sites (case studies) have been selected: the first is Mu’tah University workshops and the second is Ad-Dustour Newspaper Industry. The

reason beyond selecting these two sites was to establish a comparison between a public research facility workplace and an industrial (private sector) facility workplace. Furthermore, it was intended to have with different areas and size.

The present study has been conducted according to the following methodology and approach:

1. Literature review of the available resources on maintenance management, preventive maintenance, reliability, building maintenance, computerized maintenance management systems and international standards of different sectors, the list of references at the end of the thesis document the resources of literature used throughout the research at the two sites.
2. Interviews with the heads of the maintenance facilities, engineers, technicians and labors at both sites.
3. Field observations, i.e. checking university facilities, service units and their related heating, cooling, lighting, etc...
4. Autocad 2007 software used to create a model for the workshop workplace at Mu'tah University.
5. PROMODEL simulator used to create a model for Ad-Dustour news paper industry.

1.7 Objectives of the Present Work

The main objectives of the study were to investigate the following:

1- To study the defects of the workplace at the cases study and their reflection on employee’s performance, time duration to do their work, the health of workers and the environment of the workplace.
2- To investigate the role of engineering management on equipment, machines, and tools in the workplace.
3- To identify the faults in building in which the employees do their works.
4- Suggest a modified workplace design according to the suitability of the workers and the standards and health regulation of the workers.

Chapter Two
Literature Review

2.1 Background

The review during the present work has been made through a wide range of relevant journals *inter alia,* Journal of Industrial Engineering International; Journal of Science and Technology; Journal of International Production Research; Journal of Facilities Management ; Indian Journal of Industrial Relations; International Journal of Human Factors Modeling and Simulation; Journal of Industrial Teacher Education; International Journal of Services and Operations Management; Journal of Healthcare Forum; International Journal Of Enterprise Computing and Business Systems; Academy of Management Journal; Journal of Management Inquiry. The references listed at the end of the thesis bring to the readers the main literatures that were of great help to in present work. No previous similar work has been recorded in Jordan; however, this study has recorded number of projects that are similar in scope. The following section gives a brief on some of these studies.

2.2 Layout Design

Duffy and Tanis (1993) define layout design as the skilled and cost effective allocation of physical resources to solve immediate as well as long –term accommodation problem of people, machines, and activities–despite uncertainty, inadequate information and shifting goal-for users, customers, and society in large to embrace high culture and deep practicality. This makes layout design decisions correspond to nothing more closely than the highest levels of strategic management.

Ching (1987) defines layout design as the process of careful and deliberate design, planning, and layout of spaces within and outside buildings by deploying a set of physical, psychological and sensory (visual, tactile, auditory, thermal, olfactory…etc) design elements into an integrated coherent whole supported with available resource, in order to achieve organizational goal and meet users, activity, available space, and aesthetic requirement.

He also reported that layout design is concerned with fulfilling the following criteria:

1- Function and Purpose
2- Utility and Economy
3- Form and Style
4- Image and Meaning

The previous definitions describe layout in general and in board terms, but the following definitions define it in a more focused scope that is oriented toward the manufacturing and industrial environment.

Layout design can be defined as the process by which the placement of department, workgroups within department, workstations, machines, and stockholding point within a production facility are determined with the objective to arrange these elements in a way that ensures a smooth work flow in factory or a particular traffic in a service organization (Jacobs *et al.*, 1998, 2004). In other words it`s the location or arrangement of everything within and around buildings (Heizer and Render, 2005).

Francis *et al*. (1992) reported that the type design is defined as the spatial relationships in a facility that material move through over time. Those spatial relationships are measured in distance or feet for moves between locations, and in square feet for determining an overall score. It defines the method and resources (i.e. people, fork trucks, cranes…etc), associated costs of resources and unit loads for moving the material from location to location in the layout.

Gaither and Frazer (2001) describe layout design as the allocation of all machines ,utilities .employee workstations, customer service areas, material storage areas, aisles, restrooms ,lunchrooms ,internal walls ,offices, and computer rooms for the patterns of materials and people around, into, and within buildings. Henry (2004) defines it as the arrangement of machines, storage areas, and/or work areas usually within the confines of a physical structure, such as a retail store, an office, a warehouse, or manufacturing facility.

Slomp *et al*. (2004) describe it in brief as the physical grouping of machines and workers in a manufacturing facility.

Stevenson (2005) defines layout design as the configuration of department, work centers, and equipment, with particular emphasis on movement of work (customers or materials) through the system.

Referring to the different definitions, the researchers define layout type design as:

The intentional effort to plan, design, execute, and redesign the allocation, arrangement, and flow of physical resource as people, material, equipment and machines, non-physical resource as available space and activities, and their integrated relationships, in the space available for an organization within and outside buildings over time to achieve maximum levels of effectiveness, in a sustainable and flexible manner (Ajjour, 2005)

2.3 Computer Utilization and Layout Design

Companies tend to use computerized programs to maximize their possibilities, and to get different alternatives that can be difficult to achieve manually. A number of computerized layout programs have been developed over the past 35 years since the 1970’s to devise good layout (Jacobs *et al*.,2004).

The use of Computer –Aided Design (CAD) and other computerized visualizing tools is essential. Groover (1984) states that CAD can be described as any activity that involves the use of the computer to create or modify an engineering design.

This means that CAD can be used in many different ways and at different levels of complexity.

There are some of the advantages of a CAD as described by Groover (1984):

1) Increasing the designer`s productivity.
2) Improved quality of the design, since a CAD system allows the designer to evaluate a number of alternative solutions.

Furthermore, Fallon and Dillon (1988) reported that to increase human input to the design process, there is an increasing need for computer – based tools and methods. One of the reasons mentioned is that, given the general shortage of experienced human factors practitioners, the designers need supplementary tools that allow them to put human factors into the design process.

In product layout, the balancing of an assembly line is not mathematically easy. Companies engaged in assembly method usually work with computers with special programs which balance the line optimally. Due to the huge amount of products that can be assembled, it is probably most common that companies produce their own programs available on the market; these commercial programs must of course use some kind of programmed rules (Qiao *et al.,* 2003, and Benjafaar *et al.,* 2003).

2.4 How Technology Affects the Nature of Workplace

Ware and Grantham (2003) reported that how business transactions and interactions are conducted and managed are all shifting and at an accelerating price. The changing nature of workplace, new workplace designs, new technology capabilities and the economics of supporting and leveraging knowledge workers are discussed. Knowledge is the primary source of competitive advantage and knowledge workers drive business success. Therefore, the new ideas of creative, integrated management of knowledge workers, the places where they work and the technology tools and infrastructures they rely on reducing workforce support costs by as much as 30 per cent while substantially improving worker productivity, effectiveness and satisfaction. The trend of changing nature of work and workplace include globalization, technology advances, creativity and innovation, sustainability, knowledge and change management. The implications of technology trends affect the changes in the work environment but not all technology is appropriate. Facilities Management has to choose the most appropriate technology to apply for the users expectations.

2.5 Workplace Management Responsibility for Accident Prevention

Good management is the cornerstone of any business activity especially workplace safety management, activity and the prevention of accidents related to workplace environments and activities. The success of workplace safety programming depends largely upon what top workplace management knows and thinks about safety, what they expect from their safety program, and how much time, money, staff resources, and the amount of their own personal involvement they will invest in it. One of the primary responsibilities of business management, and those with technical control of workplace environments and activities, is some form of "production." Management and technical personnel (owners, engineers, designers, corporate executives, managers, supervisors, and other trained management or technical personnel) who control or influence the design or operation of workplace environments and activities, to various degrees, are ultimately responsible for the planning and control of the "assets of production." A natural related business management responsibility is to "protect and secure" the assets of production for future use. Assets of production typically include capital (facilities, equipment, and production materials) and labor workers. Business managers (employers) typically state that their employees and other workers who assist in the conduct of their business are their "greatest assets." For this and other reasons associated with the exercise of ordinary (prudent) care for the safety of others, the protection of the health and safety of employees and others who may be exposed to workplace hazards is a primary function. Responsibility of management and technical personnel having control over workplace and other business activities and the potential hazards to which employees and others may be exposed. Compared to their employees and others who may be exposed to business related hazards, top management and technical personnel have a higher degree of access to relevant safety information concerning reasonably foreseeable hazards associated with their business: a higher degree of overall technical knowledge relative to workplace related hazards and accident prevention; the highest degree of control (if not exclusive control) over the safety features incorporated into workplace facilities and equipment; and the exclusive ability to dictate policy and enforce work practices relative to workplace safety. As these factors will have a profound effect on the risks and resulting injuries to which their employees and others will be exposed, reasonably prudent action on the part of top management and technical personnel must focus on the control of workplace related hazards and the establishment of the basic elements of workplace accident prevention programming. Top management must budget sufficient funds to provide:

a) Required workplace related to safety activity that will be carried out by various management and supervisory personnel.
b) All necessary workplace safety supplies and equipment.

c) The training of management, supervisors, and employees in regard to required safety policies, practices, and business related standards (Nelson and associates, 1999).

2.6 Basic Elements of Workplace Safety Programming

Basic elements of workplace safety programming typically include

(a) The publication of a written statement of corporate (company) safety policy emphasizing top management's commitment to workplace safety and the prevention of accidents,

(b) A written assignment of authority and responsibility related to workplace safety,

(c) Development and conduct of workplace and job safety analysis activity designed to identify, evaluate, and prevent or control workplace related hazards,

(d) Issuing of published safety standards regarding workplace facilities and equipment associated with the control of physical hazards,

(e) Issuing of published safe work methods and procedures,

(f) Compliance with authoritative guidelines related to the control of reasonably foreseeable workplace hazards,

(g) Compliance with all local, state, federal and nationally recognized safety standards and regulations (subject to their faithfulness to the core principles of safety engineering and the cardinal rules of hazard control),

(h) Establishment and conduct of a planned safety observation and inspection program regarding workplace related activities, facilities, and equipment,

(i) Development and conduct of a management, supervisor, and worker training program related to workplace safety requirements,

(j) Emergency response planning regarding the sudden appearance or awareness of workplace related facility, equipment, or production hazards,

(k) Formal pro-active procedures for the investigation and analysis of actual and potential workplace accidents that have resulted or have a significant probability to result in serious personnel injury or property damage, and

(l) Establishment of a formal means to periodically audit management performance and safety program content and effectiveness. To be effective, and due to their importance compared to other management policies which are typically well documented, the basic elements of workplace safety programming should be in writing (Nelson & Associates ,1999).

2.6.1 Health and Safety in Engineering Workshops

There are thousands of accidents and cases of ill health reported to the Health and Safety Executive every year in engineering workshops. Almost two-

thirds of all such incidents arise from the movement of people, goods and vehicles into, around and out of workshops.

In order to maintain health and safety standards engineering workshops, it is important to identify the most frequent and serious risks and adopting the necessary precautions, taking account of time, money and resources.

Safety and health in the workplace have become an integral component to the viability of business for employers, laborer unions, governments, and environmentalists in general (Macintosh and Gough, 1998).

According to Bohle and Quinlan (2000), the cost of workplace injuries and disease is in excess of $20 billion dollars per year. Obviously, these figures are alarming and would suggest that would be a top priority for management. However, a survey from Queensland manufacturer revealed that many companies had no written policy regarding occupational health and safety and 48 percent have no formalized occupational health and safety program and Personal Protective Equipment (PPE) .There is many types of PPE designed for specific hazards and exposure. According to Canada's National Occupational Health and Safety Resource, PPE is equipment worn by a worker to minimize exposure to specific occupational hazards. Examples of PPE are respirators, gloves, aprons, fall protection, and full body suits, as well as head, eye and foot protection (HSE, 2008).

2.6.2 Hazard Identification

The first step in reducing the likelihood of an accident is hazard identification. Hazard identification is identifying all situations or events that could cause injury or illness. Eliminating or minimizing workplace hazards needs a systematic approach. It is essential to try and anticipate all possible hazards at the workplace - known as the ‘what if?’ approach.

A hazard is a source or potential source of human injury, ill health or disease. Anything which might cause injury or ill health to anyone at or near a workplace is a hazard. While some hazards are fairly obvious and easy to identify, others are not for example exposure to noise, chemicals or radiation Cameron and Duff (1999).

2.6.3 Classes of Hazard

Hazards are classified into five different types: (Occupational Health Centre 2008)

1. Physical - includes floors, stairs, work platforms, steps, ladders, fire, falling objects, slippery surfaces, manual handling (lifting, pushing, pulling), excessively loud and prolonged noise, vibration, heat and cold, radiation, poor lighting, ventilation, and air quality.

2. Mechanical and/or electrical - includes electricity, machinery, equipment, vessels, dangerous goods, forklifts, cranes, and hoists
3. Chemical - includes chemical substances such as acids or poisons and those that could lead to fire or explosion, cleaning agents, dusts and fumes from various processes such as welding.
4. Biological - includes bacteria, viruses, mould, mildew, insects, vermin, and animals
5. Psychosocial environment - includes workplace stressors arising from a variety of sources.

2.7 Workplace and Productivity

Good workplace design can make a big difference in staff satisfaction, attraction, motivation, and retention. It can also affect the level of knowledge and skills of workers, how innovative and creating they are, and how they respond to business and technological change. Poor workplace design, by contrast, is linked to lower business performance and higher level of stress experienced by employees (Amble, 2005).

This trend among employers has led to a growing recognition of the importance of designing a work environment that meets the physical and emotional needs of workers so that they may be most productive (Proper, 1998). The author emphasizes that an effective work environment should provide positive sensory stimulation through the proper use of color, lighting, aroma, space, and furnishings. These elements are seen as critical to effective work activities and workplaces, and they lead to increased productivity of employees.

A fundamental element in increasing productivity is the physical work environment. According to a report by the Rocky Mountain Institute in Training, (1997), employees could do a much better job if employers pay attention to the work environment. This question is posed in the article: “You have held contests, you offered bonuses, and you have given out t-shirts to employees who meet their productivity goals. Still, productivity could be better. What else can you do? How about changing the office or plant’s lighting? Most people are working under the glare of florescent lighting without even noticing it. How about the heating and cooling systems? Are employees as comfortable as they might be?”.

However, these are only some of the considerations that must be taken into an account when examining the work environment for maximum productivity.
In addition, a study conducted by the Commission for Architecture & the Built

Environment and the British Council for Offices found that even simple things such as good lighting and adequate daylight can reduce absenteeism by 15 per cent and increase productivity 2.8 per cent to 20 per cent (Amble, 2005).

(Means, 2002), emphasizes that there are several major factors that can enhance productivity and health while reducing absenteeism and stress. Some of these factors include higher quality lighting, positioning fixtures to avoid glare and reflection, higher levels of daylight, increased individual control of the workplace in matters of heating and cooling, improved acoustics, improved air quality, and views of nature.

Windows have also been found to play an important role in employee stress.

There is a relationship between lack of windows in the workplace and employees' feelings of job dissatisfaction, depression, and tension. A view of natural elements such as trees, vegetation, plants, and foliage was found to buffer the negative impact of job stress (Leather and Di Beal, 1998).

Color plays an important role in employees' emotional and physiological responses. Color can be soothing, invigorating, jarring, or stress-inducing. Red color, for example, has been shown to stimulate a sympathetic response. On the other hand, red color has also been shown to increase stress when compared to blue, which is more relaxing and tends to reduce stress, only later did the mood and morale of employees became factors again, and the influence of these factors on productivity was noted. For example, in the 1960s it was discovered that well-designed lighting had the effect of putting employees into a good mood, which in turn increased their productivity (Pelegrin, 1996).

Leather and Di Beal (1998) mentioned that basic lighting design of offices must take into account the amount of natural light, proper windows design, and access to a natural vegetation area. Studies of stress in the work environment pay little attention to features of the physical environment in which work is performed. Contemporary research on stress in the work environment typically focuses on psychosocial factors that affect job performance, strain employee health, and the environmental status of workspace.

(Vischer, 2005) described the habitability pyramid incorporating more detailed level of environmental comfort, psychological comfort, physical comfort and functional comfort for the workplace as follow:

According to Vischer:

1) Physical comfort is typically provided through codes, standards and norms for building safety and health: enough light, enough air, not too hot or too cold and safe noise levels that do not cause deafness. Physical comfort also includes building convenience meaning transportation access, parking, safe and effective evaluator service, an adequate number of clean and functioning toilets and effective maintenance and rep air services. Without physical comfort, a building is uninhabitable.

2) Functional comfort links the physical qualities of the environment with the requirements of users tasks. A functionally comfortable workspace is a tool for work: not just lighting, but the right lighting for the task, not ventilation, but clean conditioned air that is free of contaminants, not just heating, but thermal comfort.
3) Psychological comfort depends on owning, controlling and having responsibility for territory. Being deprived of territory is stressful, leading to frustration, low morale and sometimes aggression in the form of resistance to change.

Plant layout planning includes decisions regarding the physical allocation of the economic activity centers in all facility. An economic activity center is an entity occupying space. The plant layout process starts at an aggregate level, taking into account the different departments. As soon as the details are analyzed, different issues arise and the original configuration may be changed through a feedback process. Most layouts are designed properly for the initial conditions of the business, although as long as the company grows and has adapted to internal and external changes, a re-layout is necessary. Symptoms that allow us to detect the need for a re-layout (Chandrasekar 2011) are:

a) Congestion and bad utilization of space
b) Excessive stock in process at the facility
c) Long distances in the work flow process
d) Simultaneous bottle necks and workstations with idle time
e) Qualified workers carrying out too many simple operations
f) Labor anxiety and discomfort
g) Accidents at the facility
h) Difficulty in controlling operations and personnel.

2.8 Simulation Tools

Currently there are several commercial simulation tools available. These tools can be divided into three basic classes: general-purpose simulation language, simulation front-ends and Simulators.The general-purpose simulation language requires the user to be a proficient programmer as well as competent simulationist. The simulations are essentially interface programs between the user and the simulation language being used. The simulators of today utilize constructs and terminology common to the manufacturing community, and offer graphical presentation and animation.

The discrete event simulators are well suited for the simulation of a manufacturing system. Simulators can reduce the time required to develop a simulation model and they may exceed the capabilities of the average manufacturing engineer, thus requiring a dedicated programmer/analyst. There are

often specialized situations, and scenarios that are outside the available set of modeling constructs (i.e. objects), where the user must often resort to more intensive programming to complete the model. Recent development in simulator packages, especially in the ability to define submodels (reusable model segments), provide them with the flexibility to meet the needs of the development effort. The newest versions of simulator packages have a graphical user interface (GUI), and the use of a mouse in model building is an advantage. The computer platform is usually PC Windows/NT or a graphical Unix workstation.

Information about some simulators can be found from the following web addresses, note that there are also other simulators or simulation languages on the market:

1. Automod / Autosched http://www.autosim.com
2. ProModel http://www.ProModel .com
3. Areena http://www.sm.com
4. Factor/AIM http://www.pritsker.com http://www.symix.com
5. Witness http://www.lanner.com
6. Taylo rII http://www.taylorii.com
7. Taylo rED http://www.taylor-ed.com
8. Micro Saint http://www.madboulder.com
9. Quest http://www.deneb.com, http://www.tdm.fi,
10. Simple ++ http://www.aesop.de http://www.tecnomatix.com
11. Extend http://www.imaginethatinc.com/

2.9 PROMODEL's Simulation

PROMODEL's simulation modeling products are powerful yet easy-to-use simulation tools for modeling all types of systems and processes. PROMODEL software is designed to model manufacturing systems ranging from small job shops and machining cells to large mass production, flexible manufacturing systems, and supply chain systems. PROMODEL integrates system definition and animation development into one process. While defining routing locations, conveyors, and other elements the user essentially develops the animation layout.

The basic modeling elements in PROMODEL are locations, entities, arrivals, and processing (Benson, 1997).

Locations represent fixed places in the system where entities are routed for processing, delay, storage, decision making, and some other activity. It need some type of receiving locations to hold incoming entities, and processing locations where entities have value added to them. Anything that a model can process is called an entity. Some examples are parts or widgets in a factory, patients in a hospital، customers in a bank or a grocery store, and travelers calling in for airline reservations. The mechanism for defining how entities enter the system is called

arrivals. Entities can arrive singly or in batches. The number of entities arriving at a time is called the batch size. The time between the arrivals of successive entities is called inter arrival time. Processing describes the operations that take place at a location، such as the amount of time an entity spends there, the resources it needs to complete processing.

Yu and Duffy (2006) in their research about "Productivity simulation with PROMODEL for an automotive assembly workstation" focused on productivity issue for an automotive assembly workstation involving a lift assist device. To evaluate the productivity of the assembly workstation interfered by proactive ergonomic design, a prescriptive model of the automotive assembly system is developed and simulated with ProModel. The model and its simulation evaluated the productivity, and also determined the maximum conveyor speedby using Promodel simulation to evaluate productivity and utilization.

In a field study carried out in pulley's factory in Hong Kong Watanapa and Kajondecha *et al*. (2011) to improve the plant layout of pulley's factory to eliminate obstructions in material flow and thus obtain maximum productivity. The plant layout and the operation process of each section (i.e. sand mold, core ware house, core making, disassembly surface finishing, furnace, and inspection sections) have been investigated.

The result showed that disassembly surface finishing and inspection sections should be allocated to make the good material flow. The suitable of new plant layout can decrease the distance of material flow, which rises production.

Hasbullah (2010) stated productivity improvement plays an important role in determining whether a company can survive in the future based on customer demands it can fulfill, simulation can be utilized as a what –if analysis tool to decide which productivity improvement strategies to be adopted.

Hasbullah (2010) in his research present a simulation of current performance of outputs and profits, a simulation study on the existing production line is carried out to evaluate the production floor performance, and he came out interest results to improve the existing production line in the alternative layout.
According to Czarnecki and Loyd (2001), manufacturing factory floor simulations are invaluable tools in the implementation of lean manufacturing. Many manufacturers will not make a change to the process before a simulation is performed to determine the impact of the change. Simulation can be considered as inexpensive insurance against costly mistakes.

Jain and Leong (2005), discuss in their paper, simulation provides the capability to evaluate performance of a system operating under current or proposed configurations policies and procedures.

Lian (2007) in his doctoral research paper stated, simulation models are the final products of atoms, database and model generator. By changing the data in the

database, we can yield a simulation model that corresponds to the new data set without much effort.

In this way, different scenarios of value stream mapping can be transformed into simulation models in a short time and we can easily obtain feedback and implement improvements to the system after analyzing and comparing the outputs of simulation models. The more important features of the simulation model is that the job volumes, resource levels, performance targets, quality of service targets, etc. could be changed before running the model by a nonsimulation expert. (Diamond, *et al*. 2002) discussed identifying and specifying the role of simulation within the lean approach seems valuable and even necessary in expanding the simulation application base.

Manar (1997) discussed the guidelines for the effective utilization of simulation tools in the industrial environment to improve productivity. Adams, *et al.* (1999) gave an overview of how simulation could be used within the lean manufacturing strategy. Altinkilic (2004) in his paper on "Simulation-based layout planning of a production plant" discussed the parameters to be considered in carrying out layout design and the benefits gained in carrying out simulation analysis before implementing the actual set ups.

Ramesh , *et al.* (2009) , discussed the implementation of lean line layout for assembly of the pump with the features of Lean Manufacturing, and their case study carried out has opened up avenues to propose a ‘’new model of lean manufacturing for success in Indian industries’’.

2.10 Factors Influencing Layout

Shubin and Madeheim (2007) reported that while deciding his factory or unit of establishment or store, a small-scale businessman should keep the following factors in mind

Factory building: The nature and size of the building determines the floor space available for layout. While designing the special requirements, e.g. air conditioning, dust control, humidity control etc. must be kept in mind.

a) Nature of product: Product layout is suitable for uniform products whereas process layout is more appropriate for custom-made products.
b) Production process: In assembly line industries, product layout is better. In job order or intermittent manufacturing on the other hand, process layout is desirable.
c) Type of machinery: General purpose machines are often arranged as per process layout while special purpose machines are arranged according to product layout

d) Repairs and maintenance: Machines should be so arranged that adequate space is available between them for movement of equipment and people required for repairing the machines.
e) Human needs: Adequate arrangement should be made for cloakroom, washroom, lockers, drinking water, toilets and other employee facilities, proper provision should be made for disposal of effluents, if any.
f) Plant environment: Heat, light, noise, ventilation and other aspects should be duly considered, e.g. paint shops and plating section should be located in another hall so that dangerous fumes can be removed through proper ventilation etc. Adequate safety arrangement should also be made.

Thus, the layout should be conducive to health and safety of employees. It should ensure free and efficient flow of men and materials. Future expansion and diversification may also be considered while planning factory layout.

Chapter three
General concepts related to workplace design

3.1 General

Before starting analyzing the results of the two cases study in the next chapter, let know the concepts of modeling and simulation which will be utilized in analyzing of the workplace of the cases which had been considered in the work.

3.2 Modeling

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity. Simulation practitioners recommend increasing the complexity of a model iteratively. An important issue in modeling is model validity. Model validation techniques include simulating the model under known input conditions and comparing model output with system output.

Generally, a model intended for a simulation study is a mathematical model developed with the help of simulation software. Mathematical model classifications include deterministic (input and output variables are fixed values) or stochastic (at least one of the input or output variables is probabilistic); static (time is not taken into account) or dynamic (time-varying interactions among variables are taken into account). Typically، simulation models are stochastic and dynamic (Anu, 1997).

3.3 Simulation

A simulation of a system is the operation of a model of the system. The model can be reconfigured and experimented with; usually, this is impossible, too expensive or impractical to do in the system it represents.

The operation of the model can be studied, and hence, properties concerning the behavior of the actual system or its subsystem can be inferred. In its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest and over long periods of real time.

Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize

system performance. For instance, simulation can be used to answer questions like: What is the best design for a new telecommunications network? What are the associated resource requirements? How will a telecommunication network perform when the traffic load increases by 50%؟

How will a new routing algorithm affect its performance? Which network protocol optimizes network performance? What will be the impact of a link failure?

Simulation in which the central assumption is that the system changes instantaneously in response to certain discrete events. On the other hand, continuous simulators, like flight simulators and weather simulators, attempt to quantify the changes in a system continuously over time in response to controls. Discrete event simulation is less detailed)coarser in its smallest time unit) than continuous simulation but it is much simpler to implement, and hence, is used in a wide variety of situations (Carria, 1988).

3.4 PROMODEL

PROMODEL's simulation modeling products are powerful yet easy-to-use simulation tools for modeling all types of systems and processes. ProModel is designed to model manufacturing systems ranging from small job shops and machining cells to large mass production, flexible manufacturing systems, and supply chain systems.

ProModel is a simulation and animation tool designed to model manufacturing systems of all types quickly and accurately. Engineers and managers find the manufacturing oriented modeling elements and rule-based decision logic extremely easy to learn and use. This ease of use does not, however, come at the cost of flexibility; Promodel is capable of modeling even the most complex systems. Because it provides such an intuitive and straightforward approach to modeling, it is also attractive to professors in engineering and business programs who are interested in teaching modeling and analysis concepts without having to teach computer programming.

While most systems can be modeled by selecting from Promodel's complete set of modeling elements (e.g. resources, downtimes, locations, etc.) and modifying the appropriate parameters, complete programming capability is also provided if needed for modeling special situations. Built-in language features include if-then-else logic, Boo- lean expressions, variables, attributes, arrays and even access to external spreadsheet and text files.

Model development is completely graphical and object-oriented. To the greatest extent possible, all input is provided graphically with information being grouped by object type and presented in a table format for quick and intuitive access. For example, when the modeler defines a machine the modeler can also

define the machine's icon, capacity, downtime characteristics, input and output rules, desired output statistics, etc.

3.4.1ProModel's Modeling Elements

1) Locations

Locations are fixed places in the system such as machines, queues, storage areas, workstations or tanks to which parts or entities are routed for processing, storage or simply to make some decision about further routing. Locations may be either single unit locations (a single machine) or multiunit locations (a group of similar machines performing the same operation in parallel). Simulation results are informative and may be displayed in tabular or graphical form. Many other simulation software products require special commands to generate statistics that are difficult to interpret for non-simulationists. Promodel allows quick and convenient selection of reports and provides automatic tabular and graphic reports on all system performance measures. Output reports from several simulation runs can even be compared on the same graph.

Locations may be assigned input and output rules. Input rules are used for selecting what entity to process next, while output rules are used for ranking entities (i.e. FIFO, LIFO, user-defined) in a multi-capacity location.

The modeling elements of Promodel provide the building blocks for representing the physical and logical components of the system being modeled. Physical elements of the system such as parts, machines, or resources may be referenced either graphically or by name. Figure 4.1 illustrates the pull down menu system utilized to access the various elements of the model.

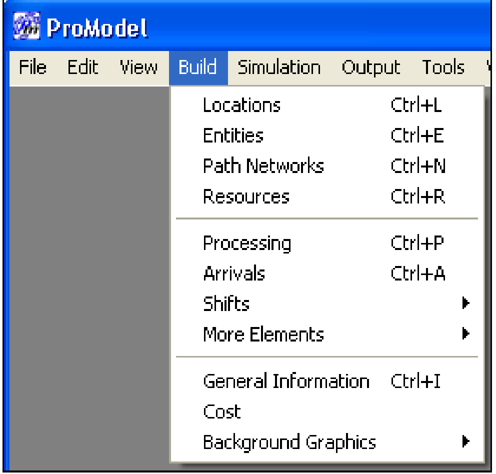


Figure 3.1: Pull Down Menu System Utilized To Access the Various Elements of the Model

2) Entities (or Parts)

Entities or parts refer to the items being processed in the system. These may include raw materials, piece parts, assemblies, loads, WIP, finished products, orders, or any other type of product that may need to be tracked as it moves

through the system. Entities of the same type or of different types may be consolidated into a single entity, separated into two or more additional entities or converted to one or more new entity types.
Entities may be assigned attributes that can be tested in making decisions or used for gathering specialized statistics. The graphic of an entity can be changed as a result of an operation to show the physical change during the animation.

3) Path Networks

Path networks are optional and define the possible paths that entities and resources may travel when moving through the system. Path networks consist of nodes connected by path segments and are defined graphically with simple mouse clicks. Multiple path networks may be defined, and one or more resources and/or entities may share the same network. Movement along a path network may be defined in terms of distance and speed or by time. Path distances are automatically computed based on the layout scale defined by the user.

4) Resources

A resource may be a person, tool, vehicle or other object that may be used to transport material between routing locations, perform an operation on material at a location، and perform maintenance on a location or other resource that is down.

5) Processing (or Routing)

This element defines the processing sequence and flow logic of entities between routing locations. The operation or service times at locations, resource requirements, processing logic, input/output relationship, routing conditions, and move times or requirements can be described using the processing element.
Operation times can be defined by constants, distributions, functions, attributes, subroutines, etc. or an expression containing any combination of these. Operation logic can include IF-THEN-ELSE statements, loops, nested statement blocks and subroutine calls. Resource related statements such as GET, USE, and JOINTLY GET with Boolean expressions and built-in operation statements such as ACCUM, JOIN, and GROUP greatly simplify otherwise complex logic in describing the processing requirements. Built-in and user-defined routing rules provide flexibility for modeling all types of routing conditions.

6) Graphics

Graphics in Promodel are realistic and easy to create. Visually realistic animation helps simulation to become an effective communication vehicle between engineers and managers. Promodel comes with an extensive library of graphics with provision to create and add other graphics to the library. Promodel’s Graphic Editor comes with a complete set of drawing tools and a full spectrum of color selections. Scaling, rotating, copying and many other editing features are available. You can even import drawings from other graphics packages. With little effort you can develop quick and simple 2D layouts, or, with little extra effort, 3D

perspective layouts. CAD layout drawings (e.g. AutoCAD) can also be brought in to use as the model background. The Graphic Editor is shown in Figure 3.2.

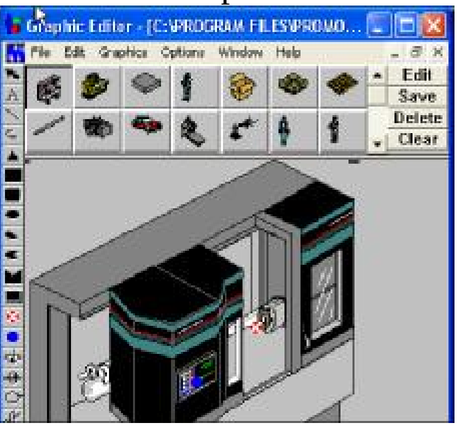


Figure 3.2: Graphic Editor

3.4.2 Running the Simulation and Animation

Models can be run for specified lengths of time or until all entities have been processed. Multiple replications may also be specified. Models may be run with or without animation.

Users can customize their output reports by selecting the type of statistics desired for each resource, location, entity, or variable. The statistics are written to a results database that can be saved as an Excel spreadsheet, or automatically converted to Access database tables. Additionally, graphic reports of the outputs can be displayed, printed, plotted, or pasted into other programs. These graphs can be individual or comparative pie charts, histograms, or time-series plots.
PROMODEL products continue to provide quality solutions using the latest in simulation technology. Promodel is an excellent tool to reduce costs, increase capacity, and improve customer service.

The workplace today is a result of historical innovations that were designed to make the workplace a productive environment. However the world of work continues to change, and the design factors that once were helpful are adding less value than they once did.
There is a set of principles and practices it can use in designing offices and workplaces.

The goal of workplace design is to provide spaces that allow people to do their jobs with maximum utility and comfort.

Here are physical design principles and physical layout elements that you should consider when designing workplaces.

3.5 Workplace Elements

1) Lighting of Workplace

Proper workplace lighting is essential because it allows employees to comfortably see what they're doing, without straining their eyes or their bodies it makes work easier and more productive, it draws attention to hazardous operations and

equipment and it helps to prevent costly errors and accident Proper lighting is also required under s.21 of the Industrial Establishments Regulation. There must be sufficient light in the workplace to ensure the safety of every worker, and there must be adequate back up lighting in an emergency or power failure.

To assess whether lighting is sufficient in your workplace, these factors must be considered:

1- Human factors
2- Area to be lit
3- Tasks to be done
4- Equipment and furniture used in tasks

2) Color of Workplace

Effectively decorating the workplace with colors that encourage creativity, productivity and positive morale, interior color design has become important to the corporate boardroom and the production manufacturing workroom. The appropriate use of color can not only maximize productivity levels and minimize fatigue, but it can also stimulate collaboration, creativity and cooperation, colors Associated with predictable psychological and physiological responses.

There is an entire psychology of color. Thus:

a. Light colors reflect light and give an open, airy sense.
b. Dark colors absorb light, close space and can make a place seem cozy.
c. Natural colors and textures are relaxing. Earth colors (brown and orange) add warmth.
d. Red colors raises emotions and creates energy.
e. Yellow can be sunny and warm but can also be dazzling.
f. Green symbolizes life and nature and can be invigorating.
g. Blue, depending on hue, can be cool (ice blue) or calm (sky or water blue).

3) Surfaces of Workplace

1- Smooth surfaces, especially light ones, reflect light that can dazzle. Matt surfaces prevent this.
2- Flat surfaces are convenient and easy, but can be boring and tiring.
3- Curves and breaks in flat surfaces can be added to break up flatness, especially where this does not cause inconvenience.

4) Distance in The Workplace

People are pretty lazy about distance. They communicate and socialize with others who are closest to them. This effect drops off sharply with distance and required effort.

1-People on adjacent desks who can see one another will converse easily on most topics.
2-More effort is needed to get up to go and see someone else even on the same floor.
3-Effort increase with going to a different building or floor, different town, different country.
4- Effective distance is a combination of physical distance, visual distance and social distance.
5-The harder it is for people communicate the less they will do so.
6-Physical distance is affected by layout designs.
7-Visual distance is affected by barriers (and transparency).
8-Social distance is affected by the opportunities people have to meet on an informal basis.

5) Aisles in The Workplace

1- Wider highways, People walk faster in wider aisles. Narrowing the aisles will slow them down.
2- Two-person aisles, Narrow aisles that cause people to touch one another (or move to avoid this) as they pass make people feel uncomfortable.
3- Long aisles are tiring on the eyes and can make navigation more difficult.

6) Doors of The Workplace

Glazed panels in doors:

1- Allow people to see who is on the other side and thus avoid hitting them. Transmit light.
2- Reduce privacy (although this can be mitigated with translucency or limited views).

Easy to open. Doors should be easy to open for anyone:

a- Auto-closing mechanisms can be heavy. Damping can slow the opening rather too much.
b- Doors that are heavy to move are uncomfortable, especially for weaker people.
c- Doors that are light can bang open, hitting a person on the other side.
d- Round handles require a greater grip than levers.

7) Ceilings of Workplace

Ceilings that absorb sound can make a big difference, especially where they are lower. Similar-looking ceiling tiles can have very different sound absorbing qualities.

Ceilings of different height add variety and interest that can always been seen.

This can include slung panels, cut-ins for such as mock roof windows, etc.

Signs and other items can be hung from ceilings to add interest and help way finding. They should not obstruct fire sprinklers, of course.

8) Signs of Workplace

Within a single area, hanging signs can be seen from a distance.

There are mandatory signs, including EHS notices, fire exit signs, etc., that must be followed.

Signs tell people where they are now, what to do and where to go; Way finding is a common use of signs.

A consistent format allows people to easily spot signs, this includes color, font, shape and size, and there are company standards for formal signs.

There are mandatory signs, including EHS notices, fire exit signs, etc., that must be followed.

3.6 Data Collection

Data Collection is an important aspect of any type of research study. Inaccurate data collection can impact the results of a study and ultimately lead to invalid results .

Data collection methods for impact evaluation vary along a continuum. At the one end of this continuum are quantitative methods and at the other end of the continuum are Qualitative methods for data collection.

Quantitative and Qualitative Data collection methods

The Quantitative data collection methods rely on random sampling and structured data collection instruments that fit diverse experiences into redetermined response categories. They produce results that are easy to summarize, compare, and generalize .

Quantitative research is concerned with testing hypotheses derived from theory and/or being able to estimate the size of a phenomenon of interest. Depending on the research question, participants may be randomly assigned to different treatments. If this is not feasible, the researcher may collect data on participant and situational characteristics in order to statistically control for their influence on the dependent, or outcome, variable. If the intent is to generalize from the research participants to a larger population, the researcher will employ probability sampling to select participants.

The interview is a flexible and adaptable way of finding things out. The human use of language is fascinating both as a behavior in its own right, and for the virtually unique window that it opens on what lies behind our actions.

The interview is “one of the most common and most powerful ways we use to try to understand our fellow human beings” (Fontana and Frey 2000). Interviews can be structured, semi-structured or unstructured. Structured interviews start with a series of pre-determined questions with a limited set of response categories and in a pre-set order. In the structured interview

Setting, the interviewer controls the pace of the interview in a standardized and straightforward manner and very little flexibility is allowed.

The semi-structured interview also commences with pre-determined questions but the order o f questions can be modified by the interviewer’s intention.

In the unstructured interview setting, interviews commence with no pre-determined questionnaires and no pre-set of order of questions, and are directed by the interviewer ’s general area of interest and concern. The form of un structured interviews is conversational and can be completely informal. Both semi-structured and unstructured interviews have controlled flexibility differentiated between two styles of interviews Respondent Interviews and Informant Interviews (Fontana and Frey 2000).

Chapter Four
Cases of Study

4.1 Case Study –One: Workshop-Mu'tah University

On, March 22, 1981, the Royal Decree was issued announcing the inception of Mu'tah University in Mu'tah town of Karak Governorate, to be a national institution for military and civilian higher education.

The twelve non-military colleges house have forty eight undergraduate programs, twenty nine M.A programs, and five Doctoral programs meeting the needs of seventeen thousand students. Mu'tah University has a five hundred and fifty highly qualified teaching members and a staff of two thousand and three hundred people. Faculty of engineering provides short courses, workshops, and consulting services in different fields of Engineering through the Southern Center for Studies and Continuing Education.

4.1.1 Carpentry Division

This workshop concerns for the manufacture of wooden furniture to all University facilities, it is also a training Laboratories for engineering college student and to help students to complete their graduation projects for students of the Faculty of Engineering. There are 12 outstanding technicians and trainers on the work of carpentry, there are a number of machines and hand tools which allow the technicians to manufacture wooden furniture.

The numbers of students attending the Carpentry workshop are about 750 students yearly. Carpentry divided to three separated areas Upholstering, carpentry machines and painting area.

International Safety Standards for Carpentry Workshop (U.S. Department of Labor,2005)

1. Helmets.
2. Safety glasses, goggles, and face shields.
3. Gloves (including chemically protective gloves).
4. Padded kickback aprons; vests; and, groin, and leg guards.
5. Lower-back supports.
6. Steel-toed safety shoes with slip-resistant soles.
7. Earplugs and earmuffs.
8. Respirators.
9. Provide continuous local exhaust ventilation on all woodworking machines. The local exhaust systems must have a suitable collector. Dust collection systems must be located outside the building.
10. Emergency alarms and communications systems to promote rapid evacuation and fire fighting response.

11. Readily accessible, portable fire extinguishers fully charged with fire retardants appropriate to the types of fires likely to occur in that area.
12. Maintain first-aid kits designed for the initial treatment of burns and smoke inhalation. These kits should be stored outside the area of fire risk.
13. Workers need first-aid training and safety tools.

i. Upholstering Workplace:

a- The Present Situation For The First Carpentry Division Units (Upholstering Workplace)

The measurements of the main working place: Length10.75m, Width 4.25m, Height 2.55cm.

1. The total space area is 45.68m ^{2}.
2. There is a store room within the main working place.
3. There are three fire extinguishers, one of them next to the entrance door while the second in middle of the room, the last one is near to the internal door.
4. There is one compressor take space about 1.25m×0.30m [6.54m²], one sewing machine [0.54m²], one rectangular workbench [3m²] and one small container.
5. There are four lighting units
6. The area is crowded with parts, tools, excess inventory and working debris around and under the workbench
7. The windows along one side of the wall are 80cm width.
8. There is one electrical heating.
9. The distance from toilet and sinks about 60 meters, which takes about three minutes.
10. Number of employees are two, working from 8am to 4pm.
11. The average temperature recorded 15°C in the winter season and 30 °C in the summer.
12. Figure 4.1 shows the Upholstering Present Workplace.

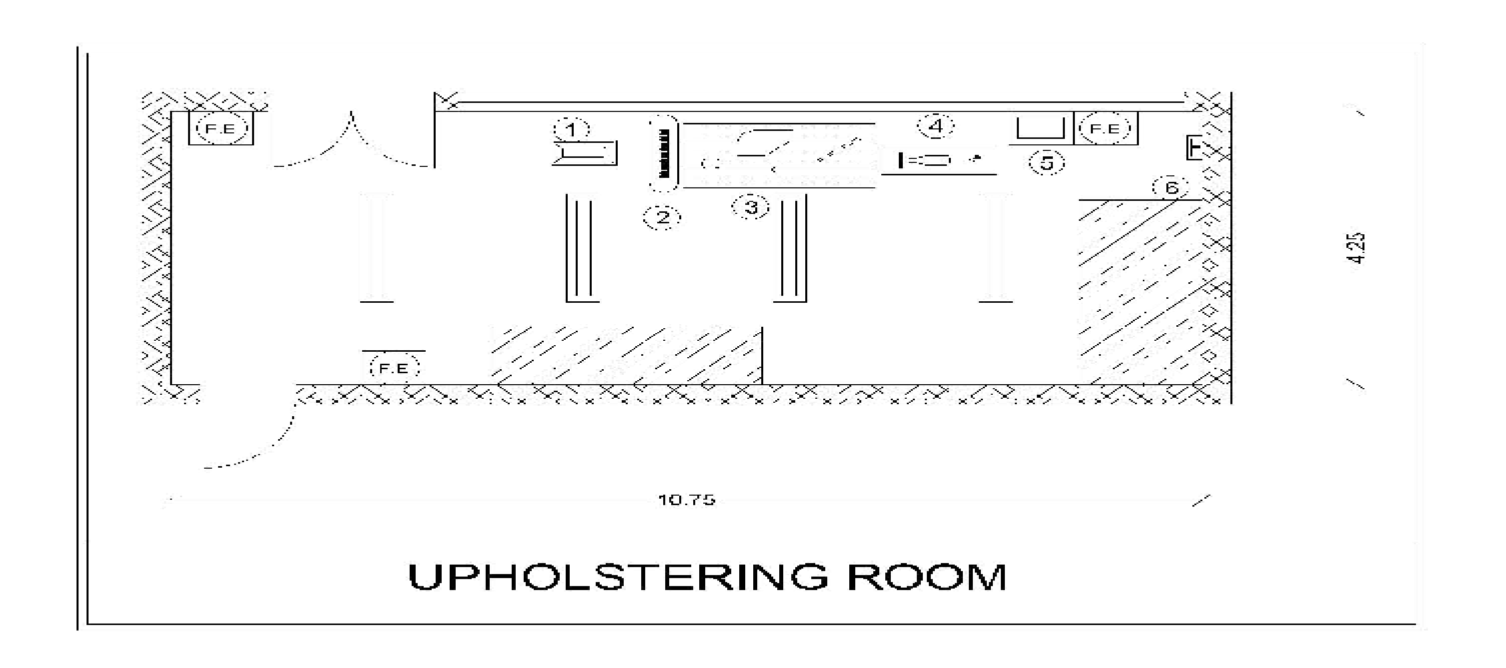


Figure 4.1: Upholstering Present Workplace

1-waste container	4-sewing machine
2-compressor	5-locker
3-workbench	6-storage space

b - Analysis of Upholstering Workplace:

The space area is too small related to the work size, there is no enough space for people to do their jobs safety, and for comfortable use for equipment.

Since the working area crowded with parts, tools, and debris around and under the workbench, and the excess inventory on the floor, also untidy and cluttered in work area, all tools and materials should be placed at a definite and well defined placed with easy reach, in front of operation at distance as near as, in the redesigned workplace there is dressing cabinet of employee suggested to be at front of working place to bring the attention of them to remember the should wearing the working requirements , which also contains personal protective equipment (PPE). Tools for the job should be organized in a tidy and logical manner so that they can be easily obtained .

The study suggested to be in the middle close to the compressor, sewing machine and workbench as shown in Figure 4.1. Also the workplace must have a big container to keep the work area tidy.

a) The compressor placed far of the door and must have covered so the employees get easy movement. It should keep a space around tidy and empty to prevent accident and fall.
b) The electrical circuit breaker must place in a prominent place and immediately in accessible position.
c) The electric main boards, circuit breakers and the connections need to be checked and maintained annually, while actually there is no any scheduled maintenance for them.
d) Hence work bench experiments have shown that a semi-circular table having a radius of 20’’ or 50.8cm from a point at 4’’ or 10.16cm allows a most comfortable position.
e) Sewing machine preferred to be located in such away to achieve the best sequence of motion. Likewise, the compressor and workbench.
f) The compressor placed far from the door and must have covered so the employee get easy movement also it should keep the space around tidy and empty to prevent accident and fall.
g) Furthermore, the present study has shown that there is a shortage in safety equipments in carpentry workshop. Azzawi (2011) mentioned in his study, that all the fire extinguishers found were expired. The new workplace design suggests four fire extinguishers must be placed.
h) There is no air conditioning as seen in the new design.
i) Workers must be provided with lighting appropriate for the nature of the work and the work location; Lighting should allow workers to move about safely without risk of accident or injury and to carry out their work effectively. The present study designed to provide the work area with extra

suitable lighting units to prevent any fatigue and give chance to the worker to do his work in more comfortable environment and to be more aquarist.

j) Figure 4.2 shows the Upholstering Redesigned Workplace.

k) The difference between the present workplace and the redesign in comparison with the international standers can be seen in Table 4.1.

Table 4.1: The Comparison of the Upholstering Present Workplace and the Redesigned Workplace.

Item Name	Present workplace	International or redesigned workplace	% difference percentage
Workplace area	45.68m²	90m²	97%
Air condition	0	1	100%
First Aid Kit	0	1	100%
Safety equipment	0	-	100%
Fire Extinguishers	3 expired	2`	100%
Temperature	15°- 30°	24° - 28°	13.3%,32%
Number of windows	Along to 10.75m	20m	86%

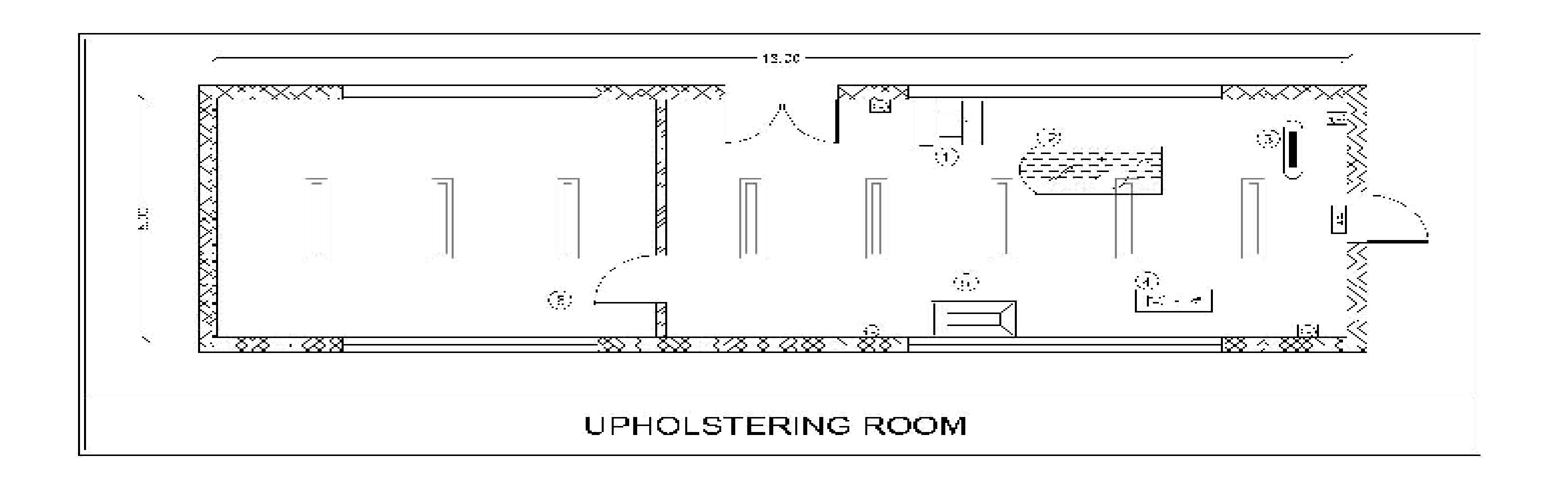


Figure 4.2: Upholstering Redesigned Workplace

1-dressing cabinet
2-workbench
3-compressor
4-sewing machine
5-waste container
6-storage room

ii. Carpentry Machine Workplace

a- The Present Workplace for the Second Carpentry Division Unites (Carpentry Machine Workplace).

1) The measurements of the workplace: Length [20] m, Width [12] m, Height [2.80] m.
2) The total space area is [240] m^2.
3) The Machines in the workplace are one combination machine, one band saw, one panel saw, sharpening machine, one thicknesser machine one spindle moulder , one workbench and two drills.
4) Number of labors & technicians are twelve, working from 8am to 4pm.
5) It has 26 lighting units and the windows area is about 14m^2 locate in two adjacent walls.
6) One air condition and two wall extractor fans.
7) There is also a gate inside the workplace leads to an unroofed and unutilized area located outside the workshop.
8) Two fire extinguishers.
9) The average distance between the machines is 2meters.
10) The average temperature recorded was 15°C in the winter season and 30 °C in summer.
11) Figure 4.3 shows the Carpentry Machine Workplace present workplace.

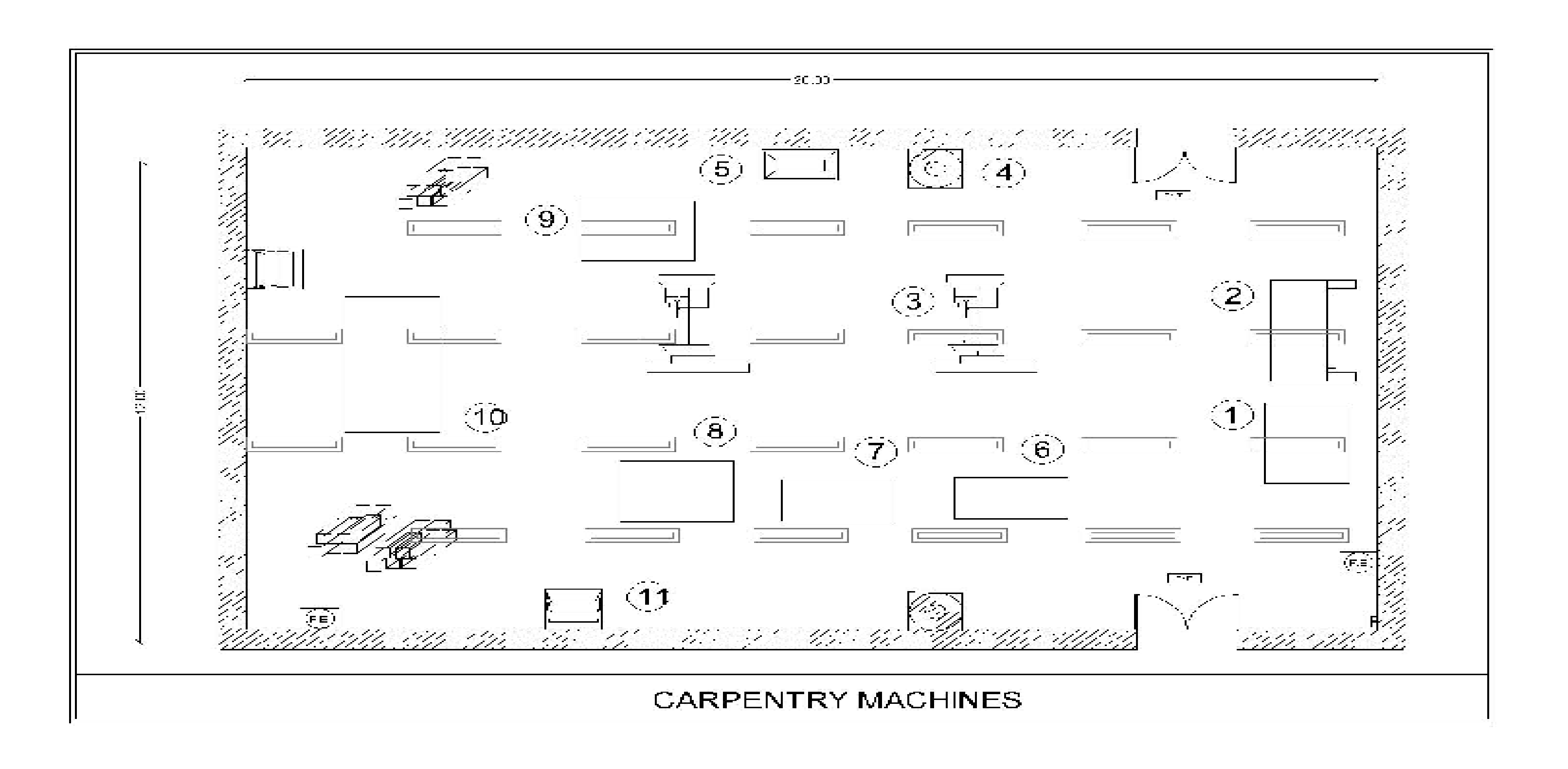


Figure 4.3: Carpentry Machine Present Workplace

1-combination machine
2-workbench
3-drill
4-wall extractor
5-waste container
6-spindle machine
7-band saw
8-sharping machine
9-Thicknesser machine
10-Panel saw
11-air condition

b- Analysis of Carpentry Machines Workplace:

1) The first and most important rule of woodworking is to wear appropriate safety equipment such as hearing protection, safety glasses, suitable boats, and gloves, in addition safety warning and notice should be prominently placed in the workplace.
2) In spite of this, nobody there abide by the rules, and no health and safety signs display, as improvement in the new design of the workplace in carpentry workshop dressing cabinet of employee suggested to be at front of working place to bring the attention of them to remember they should follow the working requirements, which also contain personal protective equipment (PPE), safety warning placed in the workplace.
3) The poor lighting in the work area was noticed. This is due to lack of lighting units and the number of windows .There must be sufficient light in the workplace to ensure the safety of every worker. And, there must be adequate back up, to achieve this and also prevent accidents as improvement in the new design. Numbers of lighting units and windows area increased at least the windows area should be 1/3 – 1/7 of the total area, so the shortage was found as: $240m^2$ (total area) $\times 1/5 = 48m^2$ this is the area which should be covered by windows. However, the windows covers area in the present workplace $28m^2$, so the shortage = $(28-48)/28 \times 100\% = 71\%$ Hence the windows in the new workplace design covered more than 1/5 of the total area to cove the shortage of the area.
4) The workplace was untidy and crowded with parts, tools, dust, and cutoff pieces. it is supposed to be cleaned and tidy. The workers should sweep up sawdust, cutoff pieces of wood, discarded sandpaper and other debris.
5) Wood dust can be irritant if it inhaled. Lack of air circulation and good ventilation was noticed.
6) Cramped body position randomly distributed machines they all rearranged in the redesign workplace according to standard criteria.
7) All the fire extinguishers were found expired. Improvement should involve new three and extra one as well as the area expanded to get more comfortable environment. The machines must rearrange to get more space between machines. More ventilation and reduce the noise and temperatures which could cause heat cramp and heat exhaustion for that the new design has provided cooling systems.
8) The problem of bad air circulation and ventilation should be solved by putting on air exhaust fan with an air extraction.
9) Figure 4.4 shows the Carpentry Machine Redesigned Workplace.

10) The difference between the present workplace and the redesigned in comparison with the international standers can be seen in Table 4.2.

Table 4.2: The Comparison of the Carpentry Present Workplace and the Redesigned Workplace.

Item Name	Workplace	International or redesigned workplace	% difference percentage
Workplace area	165m²	600 m²	72.5%
Local exhaust ventilation	0	At least 1	100%
First Aid Kit	0	2	100%
Safety equipments	0	-	100%
Fire Extinguishers	2 expired	2	100%
Temperature	15°- 30°	24° - 28°	13.3%,32%
Coverage area of windows	15m²	33m²	120%

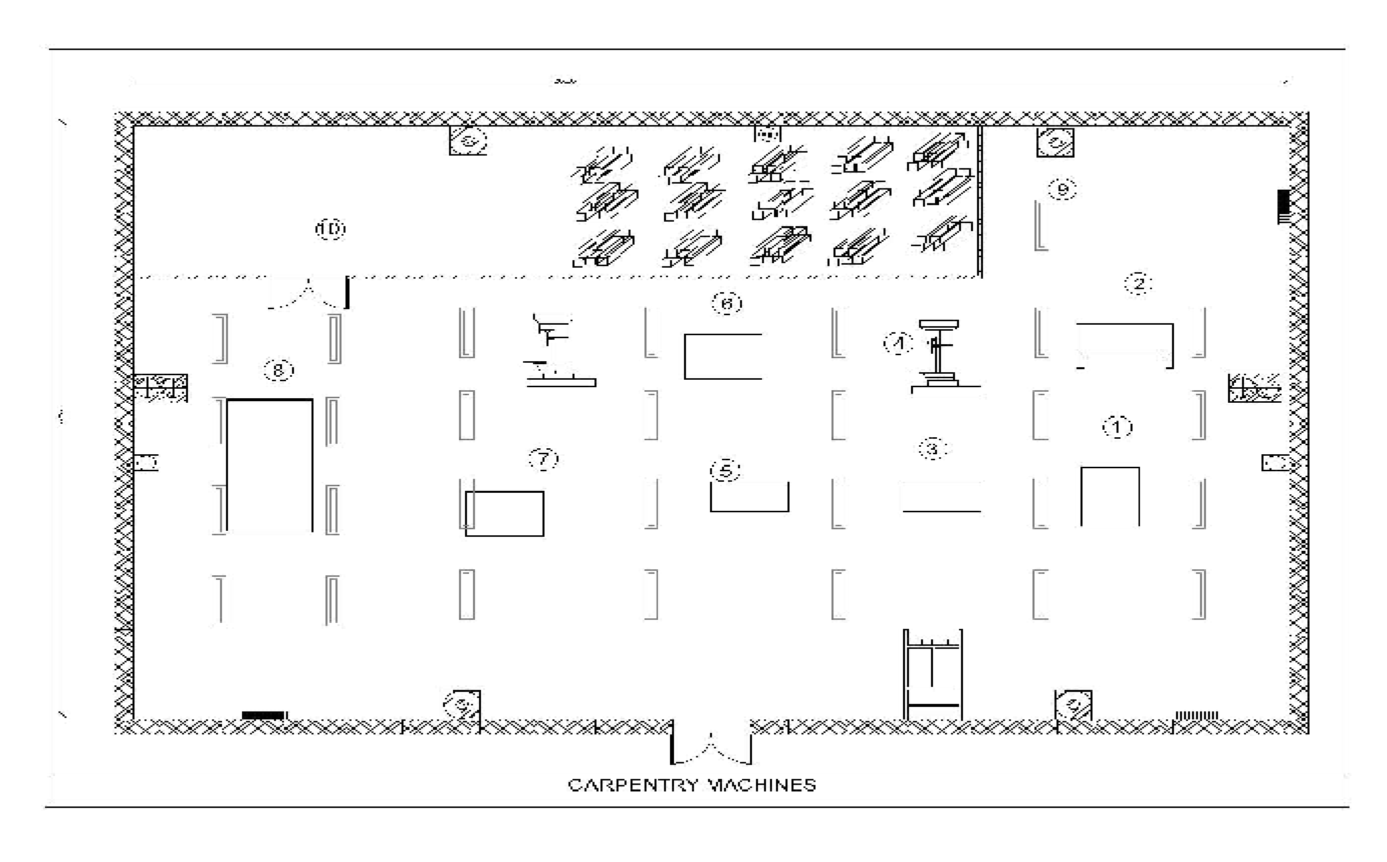


Figure 4.4: Carpentry Machine Redesigned Workplace

1-combination machine
2-workbench
3-band saw
4-drill
5-Thicknesser machine
6-spindle machine
7-sharping machine
8-Panel saw
9-air condition
10- store

4.1.2 Welding Workshop

This workshop is responsible for training the students in welding technique. The workshop also manufactures metal furniture and responsible for maintenance of all facilities at the university. There are numbers of machines and hand tools which allow the technicians to manufacture metal furniture. This workshop also provide many kind of metal equipment (dust bin, windows, doors…etc) for the local people of Karak District, in addition to the maintenance of these equipment. There are six technicians in welding workshop and there are about 750 students who are attending the welding workshop yearly.

International Safety Standards for Welding Workshop (U.S. Department of Labor2005)

1. Helmets.
2. Use enough ventilation or exhaust at the arc, or both, to keep fumes and gases from your breathing zone and general area.
3. Wear proper head, eye and hand protection, use face shields, safety glasses, and goggles as appropriate, wear dry, hole-free insulating gloves when welding or cutting.
4. Wear leather gloves, heavy shirt, cuff less pants, high shoes, and a cap.
5. Wear approved head and foot protection.
6. Wear approved personal protective devices such as ear muffs or ear plugs appropriate for the situation.
7. Keep appropriate fire extinguishing equipment nearby, and know how to use it.
8. Maintain first-aid kits designed for the initial treatment of burns and smoke inhalation. These kits should be stored outside the area of fire risk.

a- The Present Workplace

The measurements of the workplace: Length [15]m, Width [11]m, Height [3.25] m.

1. The total space area is [165] m^2.
2. The Machines in the workplace as follow , four welding machine, one spot welding machine, two manual iron cut machine, two metal folder, two stable drill and one workbench.
3. Number of labors and technicians are six working from 8am to 4pm.
4. It has 15 lighting units, 4 of them broken
5. 2000m^2 outside areas uncovered 80%of the work done there.
6. Small ware store 9m^2 inside the workplace.
7. One sink next to the internal door which is lead to the outside area.
8. Two wall extractor fans, two air conditions.
9. Three fire extinguishers.
10. The windows along one side of the wall are 1m width.

11. There is inside the workshop an internal door opens to an opening uncovered outside area.
12. Another inside workers office $10m^2$
13. The average temperature recorded 12° C in winter season and 31° C in the summer.

Figure 4.5 shows the Present Welding Workplace

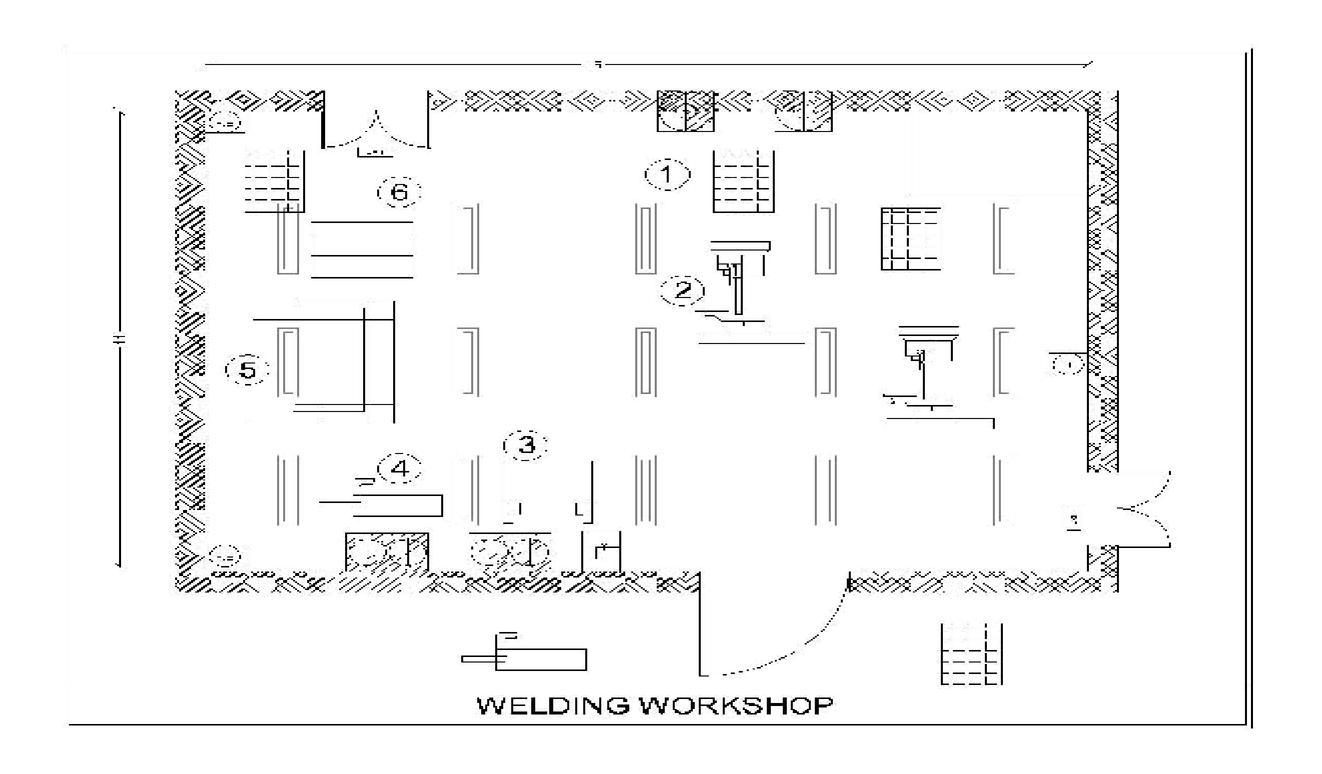


Figure 4.5: Welding Workshop Present Workplace

1-Welding machine
2-Drill
3-workbench
4-manual iron cut machine
5-iron moulds
6-spot welding machine

b- Analysis of Welding Workplace:

The space area should be wider than the present workplace, about 80% of the work done in the uncovered outside area.

1. One iron cutter and one welding machine are placed in the outside area.
2. The outside area could be utilized after covering it; it would be suitable place for store done work.
3. During working hours the temperature in all workplace inside buildings shall be reasonable there is in present workplace fluctuation of temperatures in winter and summer consequently will affect the performance and productivity of employees. Because of two main reasons the first is an unavailable cooling system and heating system, the second is being the work area opening to the outside.

   To solve this problem it is suggested, to have more space covered area from the outside. Building cooling and heating system is necessary.

   Common causes of ill health are:

1. Inhalation of harmful welding fume,
2. Unsafe handling of work pieces and welding equipment, particularly gas cylinders
3. Noise, particularly from plasma arc cutting, gouging operations and weld preparation
4. Burn from ultra violet radiation, including ‘arc eye
5. Vibration during grinding for weld preparation
6. Discomfort from heat and uncomfortable postures.

Common causes of accidents are:

1. Falling gas cylinders
2. Particles entering unprotected eyes during chipping after welding
3. Electric shocks from welding equipment
4. Fires started by flames, sparks and hot material from welding and cutting processes
5. Fingers being crushed between the electrodes of fixed resistance welding machines

All the fire extinguishers were found expired, so it should be replaced with new three and extra one due to the expansion of the workplace.

It is also noticed the inappropriate lighting in addition, to the few numbers of light units, as improvement more units placed in the new design.

Should leave enough space between each machines at least three meters to get more ease of movement for the workers and keep high level of safety because it was clearly observed the difficulties suffered by employee, this improvement will also be useful to the climate of the workplace by distribute the dust in different far away area which reduce inactivity and respiratory diseases that may be happened

to the employees such as dyspnea and asthma. local exhaust ventilation should be placed .

Overexposure to welding fumes may result in symptoms like metal fume fever, dizziness, nausea, dryness or irritation of the nose, throat or eyes. Chronic overexposure to welding fumes may affect pulmonary function. Prolonged inhalation of nickel and chromium compounds above safe exposure limits can cause cancer. Overexposure to manganese compounds above safe exposure limits can cause irreversible damage to the central nervous system ‹including the brain. Symptoms may include slurred speech, lethargy, tremor, muscular weakness, psychological disturbances and spastic gait.

The workers have not abided by the workplace safety standards and regulations. Every employee must be informed be safety standards in the workplace OSHA requires that all safety information be posted, where every employee can see it. Inadequate lighting in the work area. For processes such as welding, the primary purpose of ventilation is to remove air contaminants from the worker's breathing zone.

Ventilation strategies fall into three general categories:

1. Natural Dilution Ventilation
2. Mechanical Dilution Ventilation
3. Local Exhaust Ventilation

Dilution ventilation adds new fresh air to an area and can be accomplished by non-mechanical means such as opening windows and doors, or mechanical means such as wall and roof exhaust fans.

By opening doors, windows and other openings in a building's structure, fresh air can be added to an area to decrease the concentration of an airborne contaminant and eventually remove it.

Mechanical dilution ventilation uses wall fans, roof exhaust fans, or other mechanical means to prevent airborne contaminants from entering a worker's breathing zone.

In the redesign workplace dressing cabinet of employee suggested to be at front of working place to bring the attention of them to remember the working requirements, which also contain (PPE).

1. Local exhaust ventilation (LEV) is always the preferred method of removing welding fumes and gases. It exhausts or removes the toxic gases, fumes, dusts and vapors before they can mix with the room air.
2. Figure 4.6 shows the Redesigned Welding Workshop Workplace

The difference between the present workplace and the redesigned in comparison with the international standers can be seen in Table 4.3, and Figure 4.7 illustrates The Current Workshops Area Compared with the Redesigned.

Table 4.3: The Comparison of the Welding Present Workplace and the Redesigned Workplace.

Item Name	workplace	International or redesigned workplace	% difference percentage
Workplace area	240 m^2	600 m^2	150%
Local exhaust ventilation	0	At least 1	100%
First Aid Kit	0	2	100%
Safety equipments	0	-	100%
Fire Extinguishers	2 expired	2	100%
Temperature	12°- 31°	24° -28°	6.25%,37%
Coverage area of windows	28m^2	48m^2	71.4%

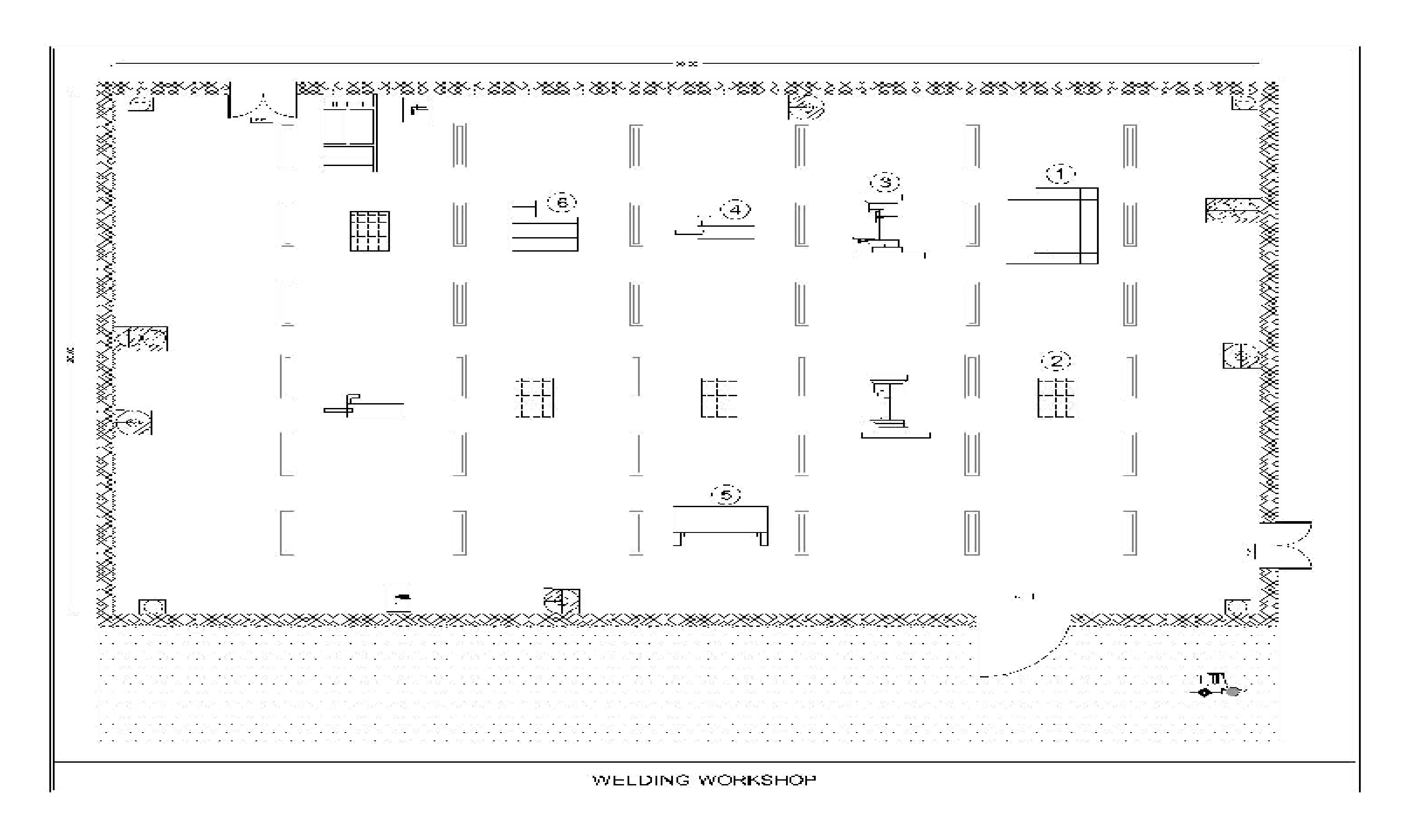


Figure 4.6: The Welding Workshop Redesigned Workplace

1-iron moulds
2-welding machine
3-drill
4-manual iron cut machine
5-workbench
6-spot welding machine

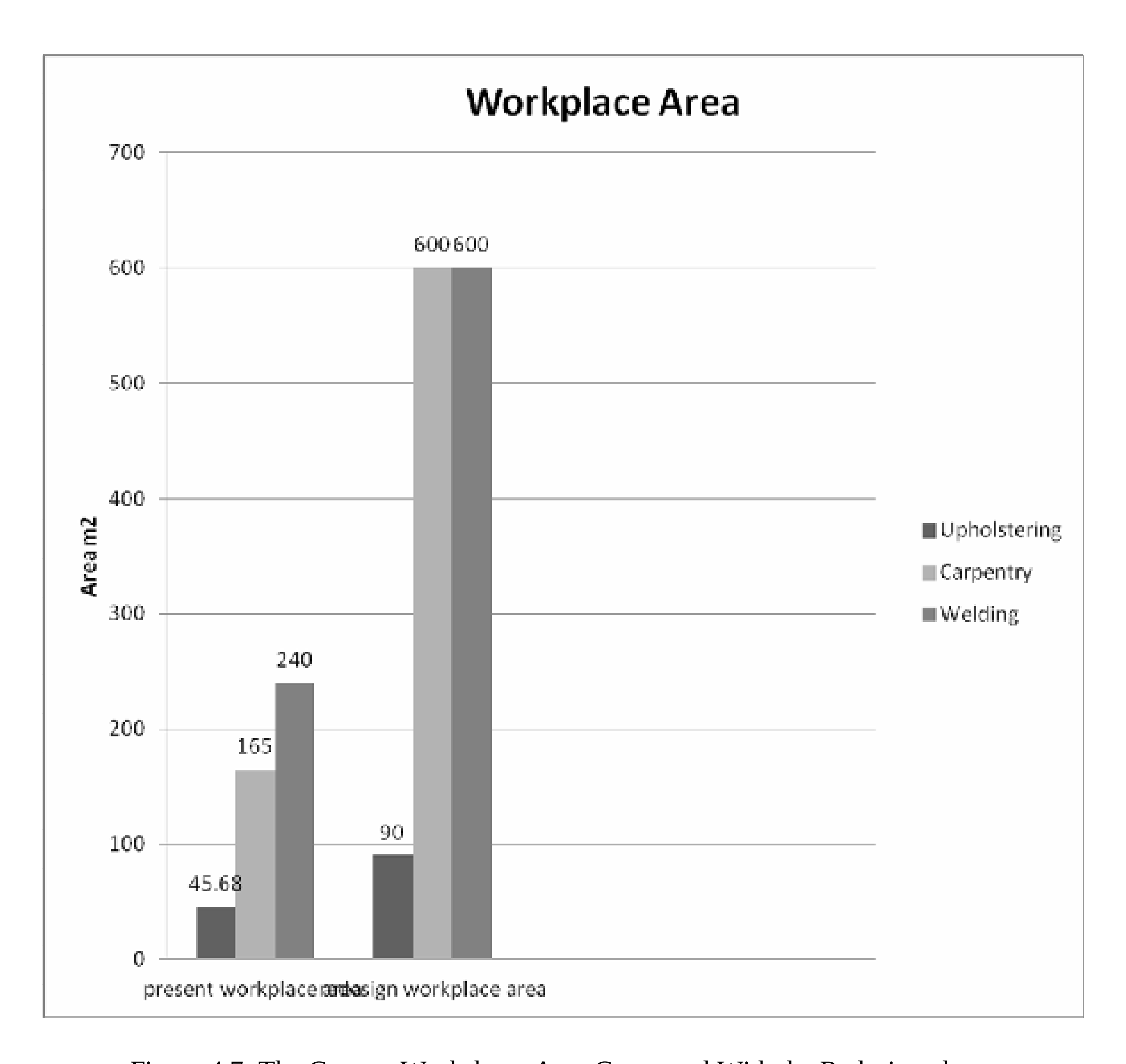


Figure 4.7: The Current Workshops Area Compared With the Redesigned.

4.2 Case Study –Two: Ad-Dustour Industry

The Ad-Dustour is daily newspaper published in Jordan. Its headquarters is in Amman, Jordan. It is owned by the Jordan Press and Publishing Company. The first issue of the newspaper was published on Tuesday 28 March 1967. The Jordan Press and Publishing Company was a private company until 1986. Ad-Dustour the oldest daily newspaper in Jordan, has led the press industry to be better, wider and more modern horizons since its inception in 1967.

a- The Present Workplace

The following section gives a brief “physical” description of the study workplace which consists of four levels:

1- Basement floor: this floor is made of two rooms; each contains one Roland machine which is press machines that transfer the content of plates on to the paper directly. One shearing machine is placed in a corner within this floor as well. This machine has two functions, the first is to make the necessary cutting for printed material and papers produced from the Roland machine and the second is for trimming the booklets produced from the binding process taking place at the Binding Department. The basement floor includes also a $4 \times 4m^2$ store that is used to store all printed material that is ready for distribution.
2- Floor one: this floor is fully assigned for the Binding Department which has three big machines located randomly in the space, used for folding, collecting and gluing.
3- Floor two: the floor is utilized by the Computer to Plate Department (CTP). In this department, “imaging technology” is used where image is created in a Desktop Publishing (DTP) application and then transferred directly to a printing plate.
4- Floor three (roof): this floor is assigned to include facilities such as , prayer area, cafeteria and toilets.

Table 4.4: Table the Employee Walking Distances and Durations.

Description	Distance	Time
Transfer the plate from the CPT to Roland 200 and Roland 700 from the upper floor to the ground flour (manually)	70m	06:50:51
Transfer the works From Roland 200 to the cutting machine	15m	00:20:00
To the cafeteria, W.C and Masjid in the 2nd floor	100m	09:50:00
From the cutting machine (by elevator) to the department of binding	–	02:00:00
From the cutting machine (by stairs) to the department of binding	24 steps	2:15:00
From the cutting machine to the bookstore	20m	3:00:00
From Bookstore to shipping	24m	3:00:00
From Department of to machine area	22m	3:00:00

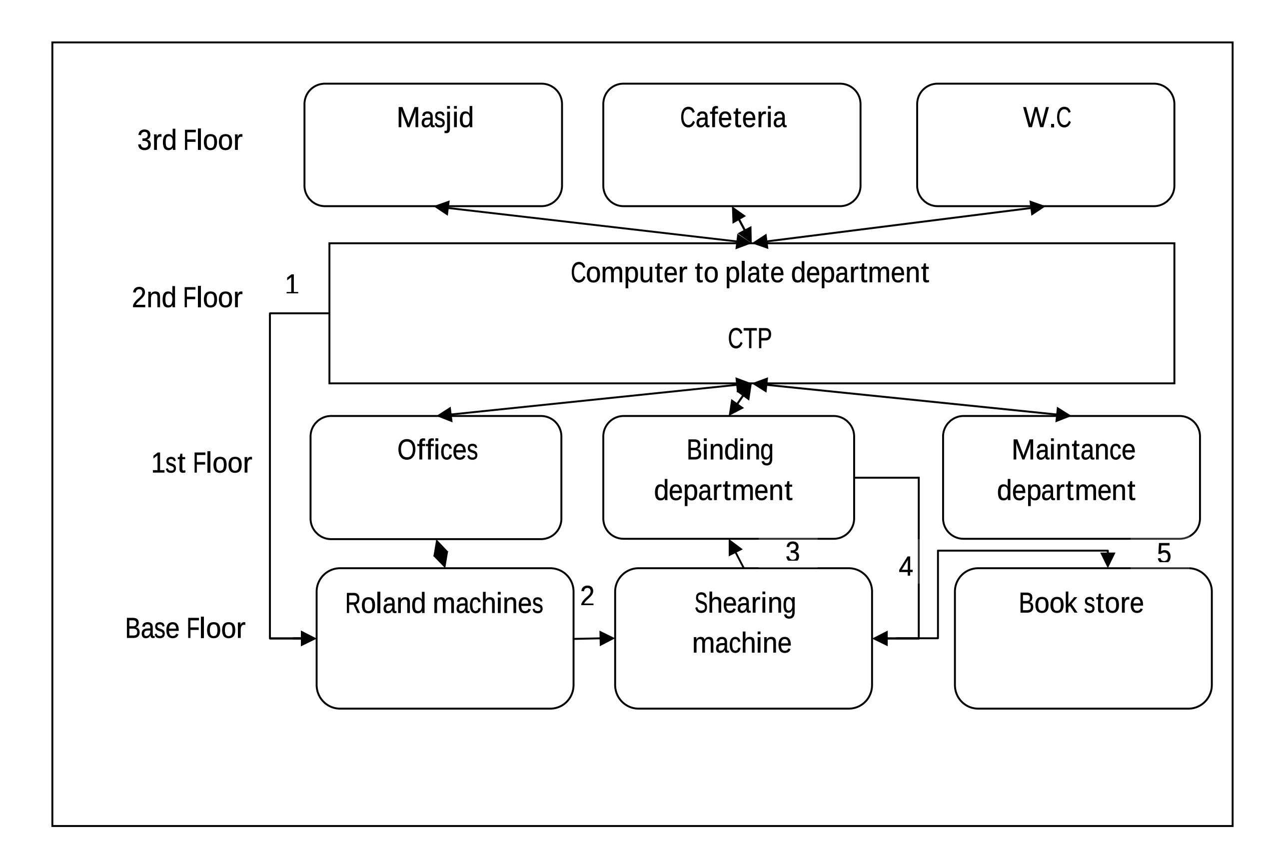


Figure 4.8 Schematic Representation of Ad-Dustour Industry Present Workplace.

b- Analysis of the Workplace:

Generally speaking, good layouts provide a number of advantages including:

1) Reduce bottlenecks in moving people or material,
2) Minimize materials-handling costs,
3) Reduce hazards to personnel,
4) Utilize labor efficiently, increase morale ،
5) Utilize available space effectively and efficiently,
6) Provides flexibility,
7) Provides ease of supervision.

However, the analysis of the study workplace (Ad-Dustour Newspaper Industry) has shown that there are a set of observations that could be summarized as follows:

1. The lighting units in Binding Department are not enough and therefore, extra units should be installed,
2. Space within the current layout of the workplace is not effectively utilized (i.e. a lot of space is wasted by large distance between the different machines and departments),

3. A number of stuff and material items are not in use and found on the floor which may increase bottlenecks in moving people or materials,
4. The indirect path between the CTP and ROLAND machine and Binding Department which increases the time needed for material transferring.
5. No safety signs were noticed within the workplace. Furthermore, the staffs do not abide of the regulation and healthy standards such as PPE. This issue is highly important and should be reconsidered.
6. The poor environment within the workplace particularly the ventilation conditions. According to safety and environmental requirements and standards in Jordan and globally, at least two local exhausts ventilation should be installed within the work area.

As an early conclusion and recommendations on the above analysis, the following would enhance the layout design of the study workplace at Ad-Dustour Newspaper Industry:

1- Relocating the CTP Department according to model shown in Figure 4.8 where it becomes closer to the other related departments and machines. This would contribute to time saving and increase the efficiency of handling the plates from the CPT department to the ROLAND machines.
2- Avoiding the use of stairs by the staff and minimize the efforts exerted by them to access the different departments and machines that were located in different floors at the workplace. This is particularly important in terms of the efforts requested from the staff to go up and down the stairs taking into consideration the double and extra efforts requested for ascending to the upper floors.
3- Placing the cafeteria, prayer area and toilet facilities within the same floor of the work place in order to reduce the time needed to reach them by the staff.
4- Placing all the departments within the same floor would also contribute to the reduction in electricity consumption as the staff will not be in need to use elevators to transfer the work between the different floors i.e. avoid the vertical movements so reducing the time and the effort, taking into consideration that fact that the electricity used per floor (one direction, 3 meters): 2.5 Watt/hour would be saved.

In conclusion, the distance of workflow from the CTP Department to the end point of the production line was found to be too long path; however, the current layout could be modified and enhanced in order to reduce such long distance. This proposed “redesigned” and modification will not only result in improving workflow but also avoiding accidents that may occur due to the transfer of different types of material and objects.

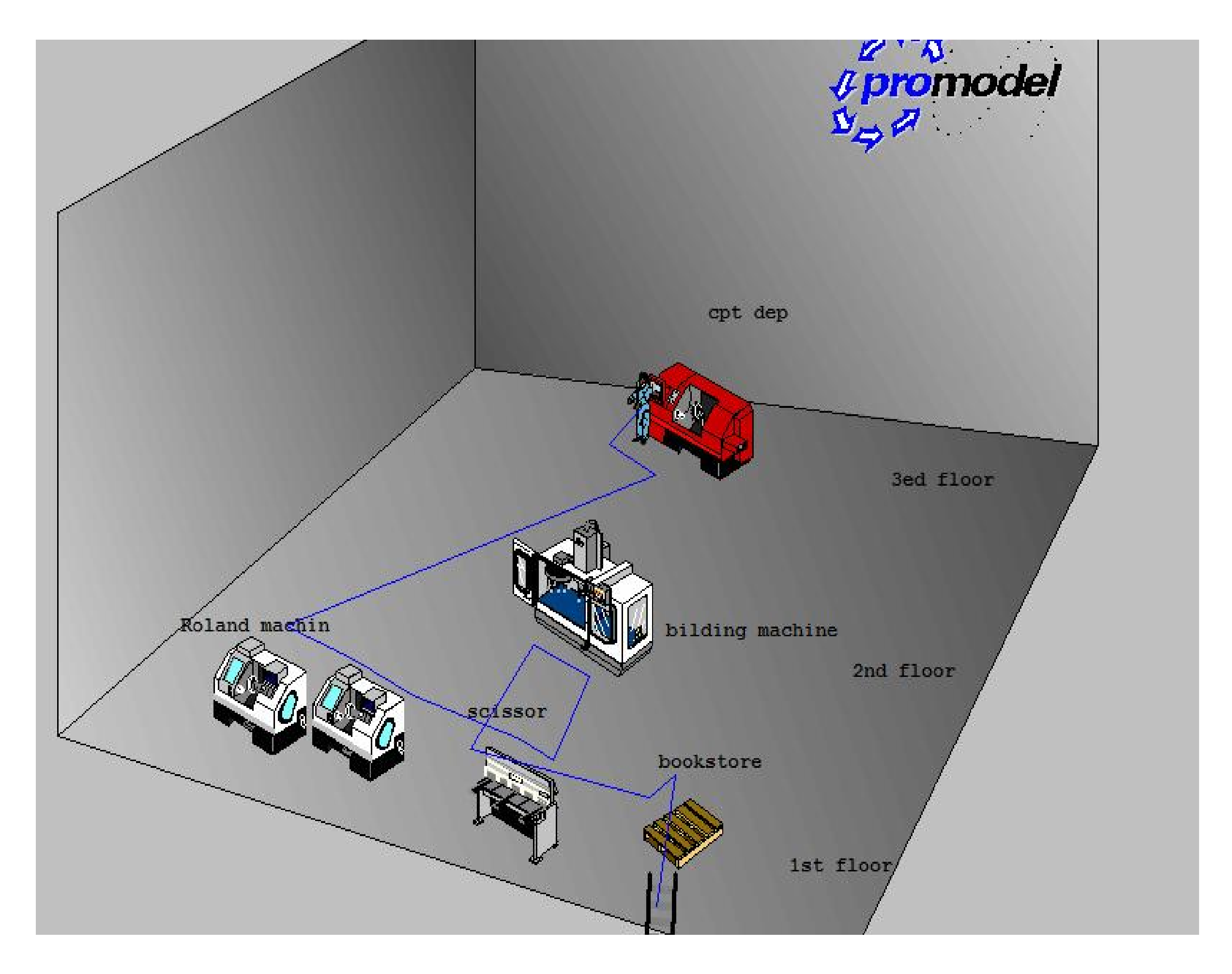


Figure 4.9: The Model Represent the Physical Layout of Ad-Dustour Industry Present Workplace.

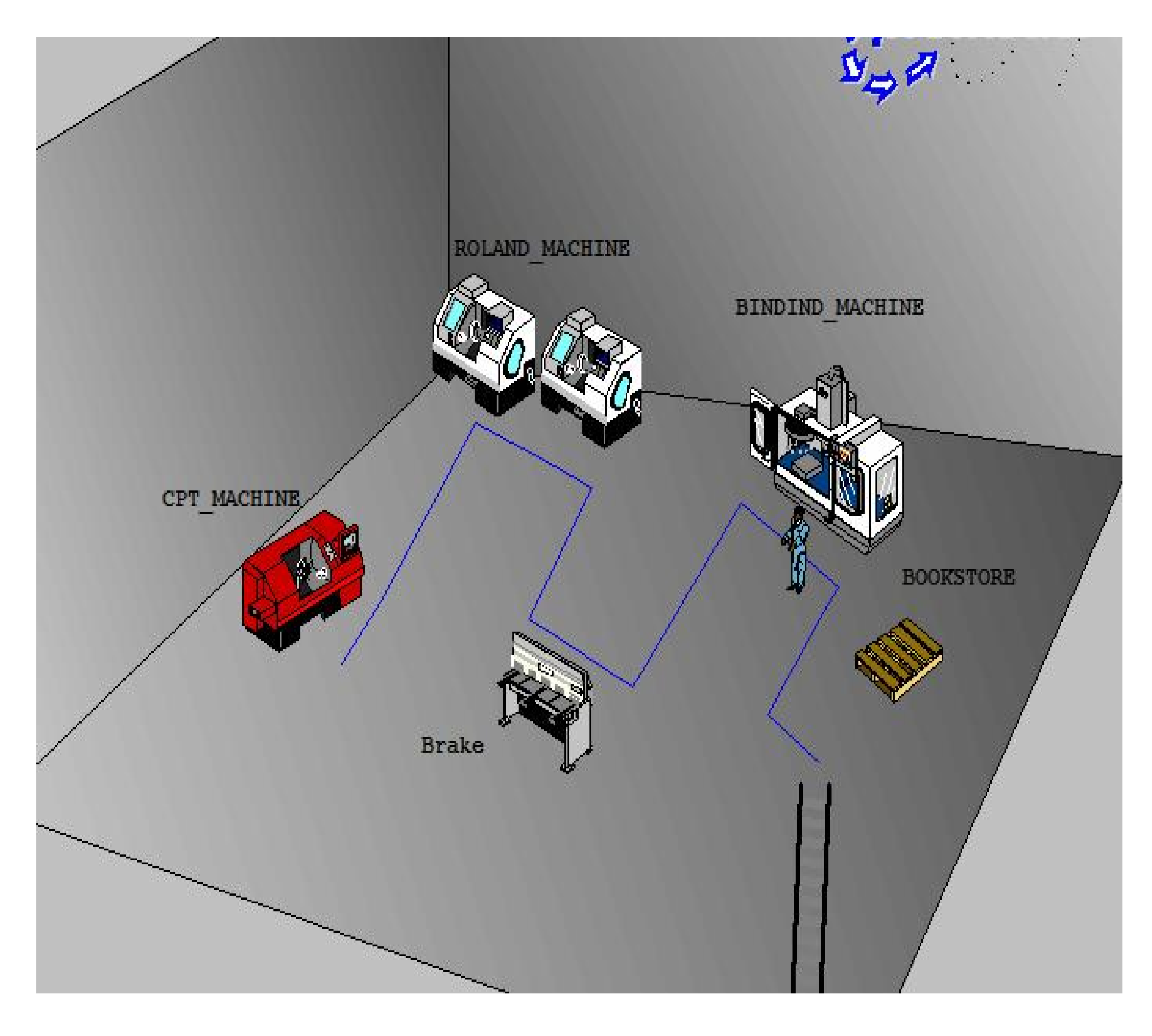


Figure 4.10: The Model Represent the Physical Layout of Ad_Dustour Industry Redesigned Workplace.

Chapter Five
Results, Discussion and Conclusions

The present study has conducted an analysis for the workplace layout at Al-Doustour Industry and Mu'tah University's Workshops. The study showed that both locations need more attention in the design in terms of minimizing the total cost of materials and efforts in a way that improve quality, productivity and efficiency.

Computerized programmes are extensively used nowadays by several companies, institutions and people to get different alternatives that can be difficult to achieve manually.

5.1 Al Doustour Industry Case Study

The industrial engineering and good management play a great role in directing and leading people for effective planning for their workplace. This design and redesigned models will make the work much better, faster, safer, and finally reducing the cost. Engineers make significant contributions to manufacturing companies by saving money and at the same time, making the workplace better for fellow worker.

An extensive assessment was performed for the effective facility planning at the workplace. The early results have shown that the existing workplace has been designed, constructed and later expanded in different phases during the last 20 years. Therefore, the existing layout design is an accumulation of a variety of views, thoughts and decisions.

According to the different layout designs proposed and adopted for the several expansions that took place during the last 20 years, materials handling costs were not considered efficiently in any of the previous designs and extensions. This was clearly reflected in the plan layout of the Al-Doustour Industry.

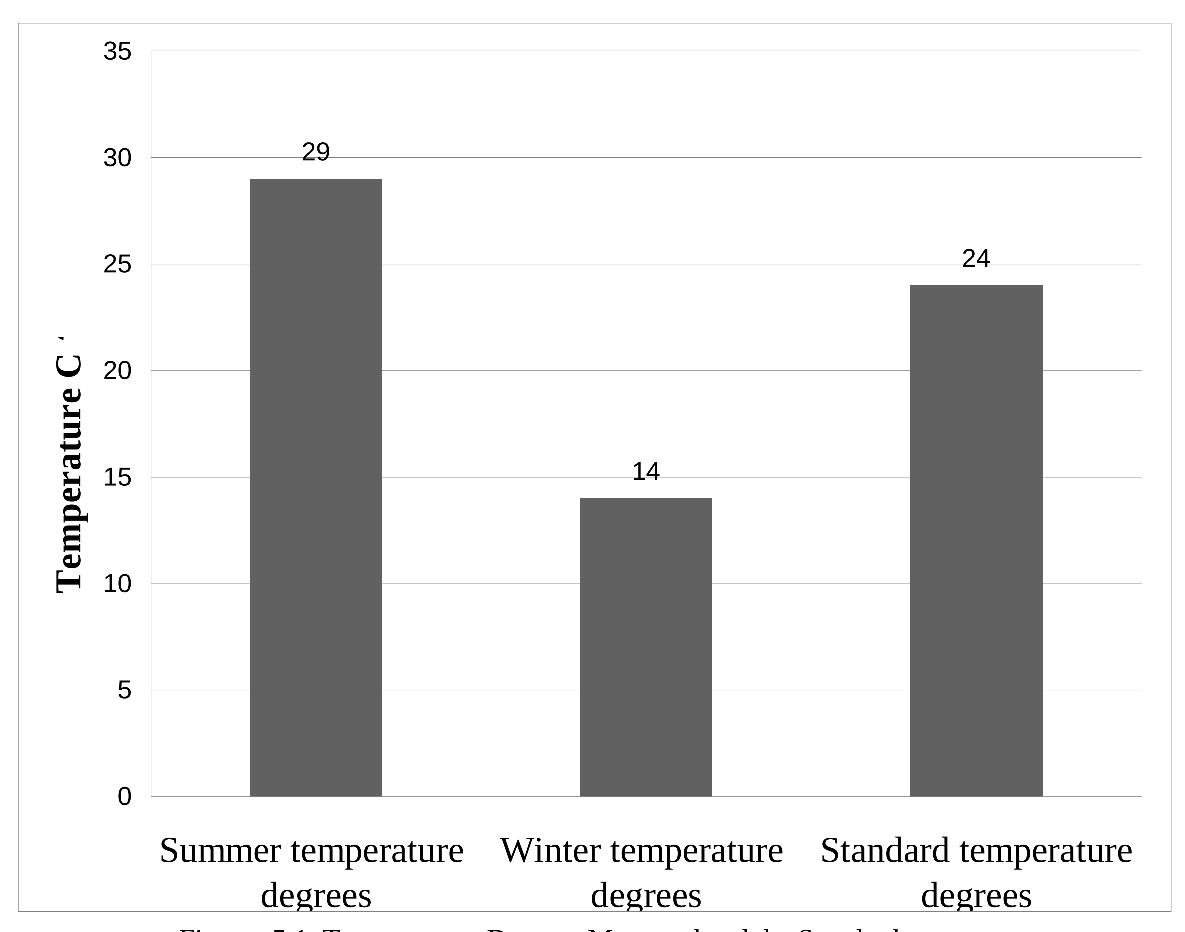
This section deals with the description of the main results achieved throughout the study. The focus of the description is on the facility layout problems which are related to both material handling cost and efforts required to carry out the work within the facility. Minimizing material handling cost and other objectives (e.g. productivity and quality of products, etc.) are achieved simultaneously.

5.1.1 Workplace Element and Environment

Temperature

The workplace was found to lack air conditioning system. This was clearly from the temperature measurements collected throughout the study, particularly in summer time. It was clear that the staff are suffering from high temperature in summer, especially that these temperatures reached 40°C in several days during

the course of this study (2011). This situation was manifested by the poor design of corridors and pathways. Figure 5.1 illustrates the fluctuation in temperatures in summer and winter seasons compared with standard temperatures.



Figures 5.1: Temperatures Degrees Measured and the Standard temperatures

The figure above shows the big gap between the measured temperatures and the standard degree during summer and winter seasons. However, the high temperatures in the workplace reduced worker morale and productivity, and increased absenteeism and mistakes. Inexpensive, portable fans produce air movement which evaporate

perspiration cooling the body. Fans installed at the roof and on walls will reduce hot air gathering and may supply fresh cooler air from outside, Protecting workers from the effects of high temperatures.

Physical Design (Windows)

The Windows area at Al-Doustor site compared with total space area were not within the limits of the standard measurement. This was due to lack in the

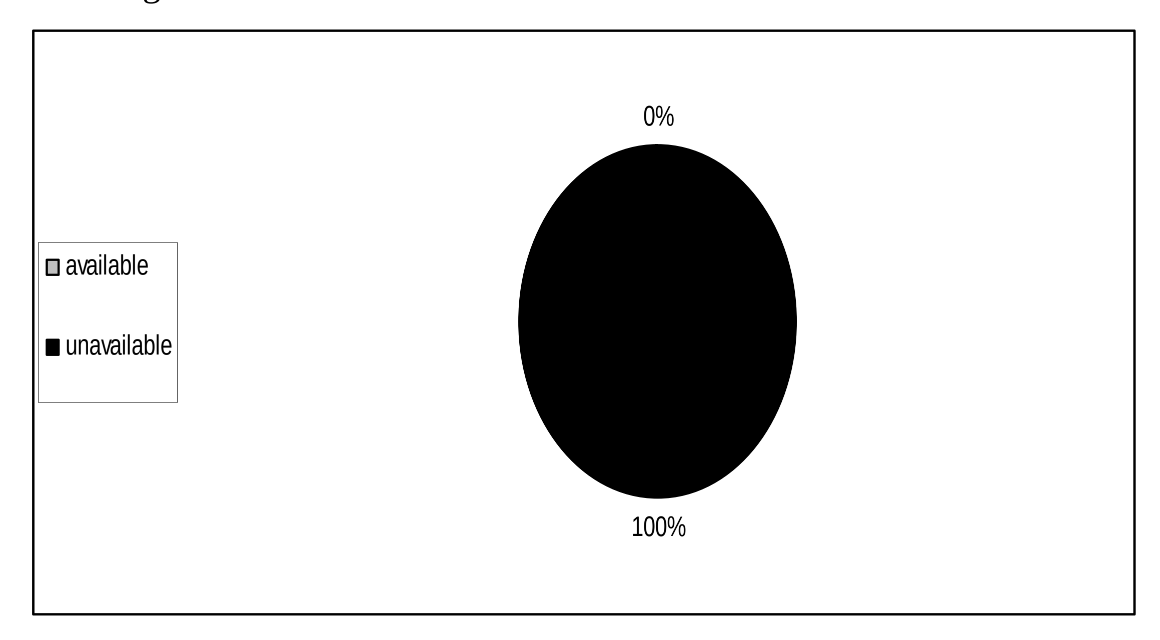
initial study and future planning. Therefore, artificial lighting was used more than the natural lighting which causes increase the total cost.

Safety

Only 5% of the employees abide by using the safety equipment products and the PPT (e.g. Gloves, Lab Coats, Eye Protection, and Respirators), that caused increasing in accidents and injuries.

As the number of physical health conditions increases, the odd ratio for an accident increases with employees.

Employer must ensure that qualified first-aid can be provided at all times. Appropriately equipped first-aid kit stations shall be easily accessible throughout the place of work .The availability of first-aid kit in at Al-Doustor was found 0% as shown in Figure 5.2



Figures 5.2: The Availability of First-Aid Kit in Al- Doustor Industry.

5.1.2 Simulation experiment

Simulation Model

In the model shown in figure 4.7, the machines location placed according to the physical layout and created the process flows of each product as follows the flow chart in Figur4.7 .The simulation technique is added to plant layout design to show more information about the design such as total time in system, waiting time, and utilization. Finally, the simulation system sends back overall results as a report.

In the plant layout design model, there are many inputs needed for searching an optimal plant layout, such as number of departments, department area,

department location, number of products, number of machines, production rate and sequence.

The elements were in the model, the CTP department, the two Roland machines, the binding department, the shearing machine and the bookstore.

After selection the entire element, the simulation time adjusted for 8 hours.

The simulation results show information such as total time in system, waiting time, utilization, and idle time.

Finally, all inputs will be used to simulate the model and show the measurements and percentages for several factors and elements in the model for the existing situation of the workplace and the modified one.

Figures 5-3 and 5-4, Table 5.1 and 5.2 illustrate the utilization of the location in the model.

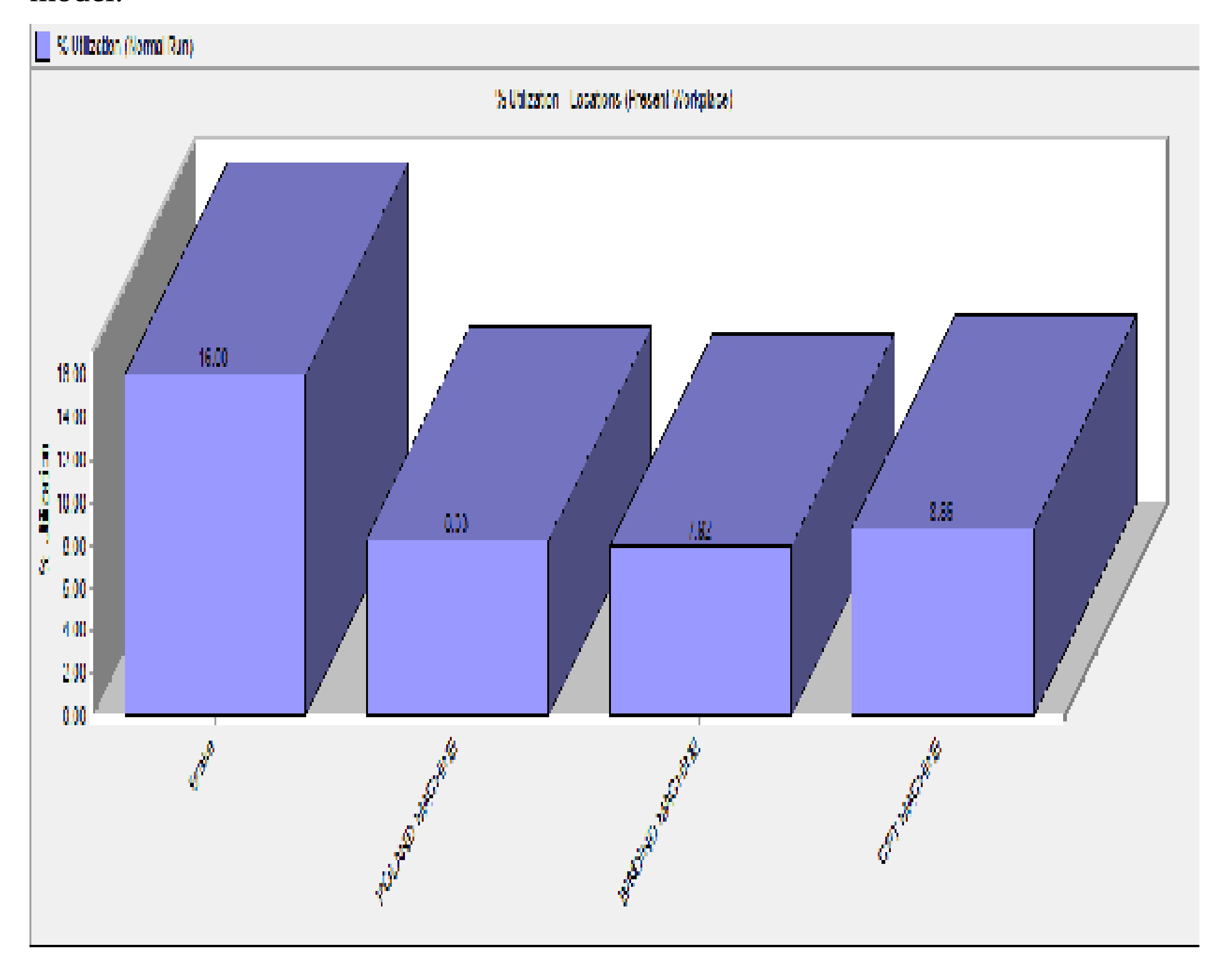


Figure 5.3: The Utilization of the Location in the Model of Present Workplace.

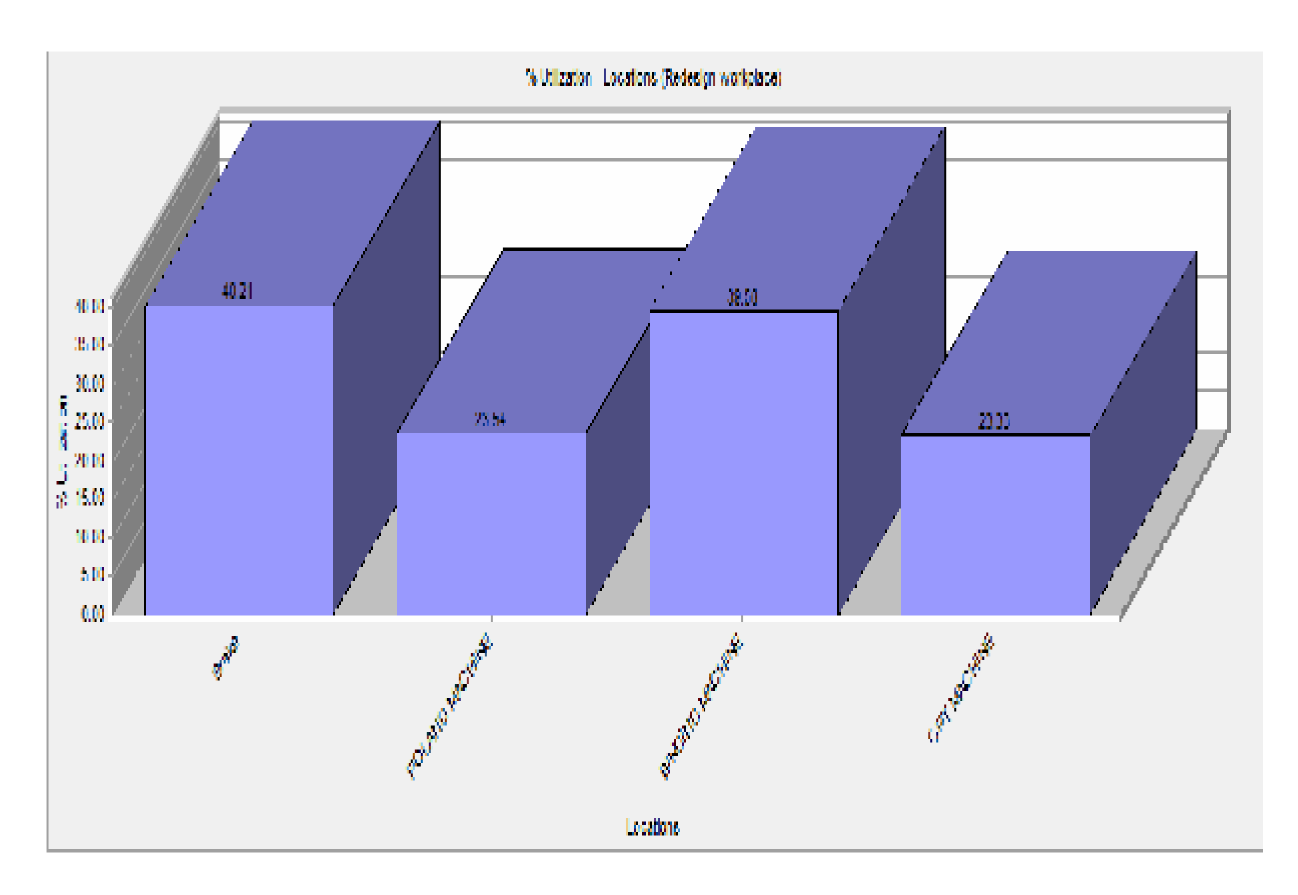


Figure 5.4: The Utilization of the Location in the Model of Redesigned Workplace.

Table 5.1: The Utilization of the Location in the Model of Present Workplace.

Location	Percent %
Brake	40.21
ROLAND MACHINE	23.54
BINDIND MACHINE	39.58
CTP MACHINE	23.33

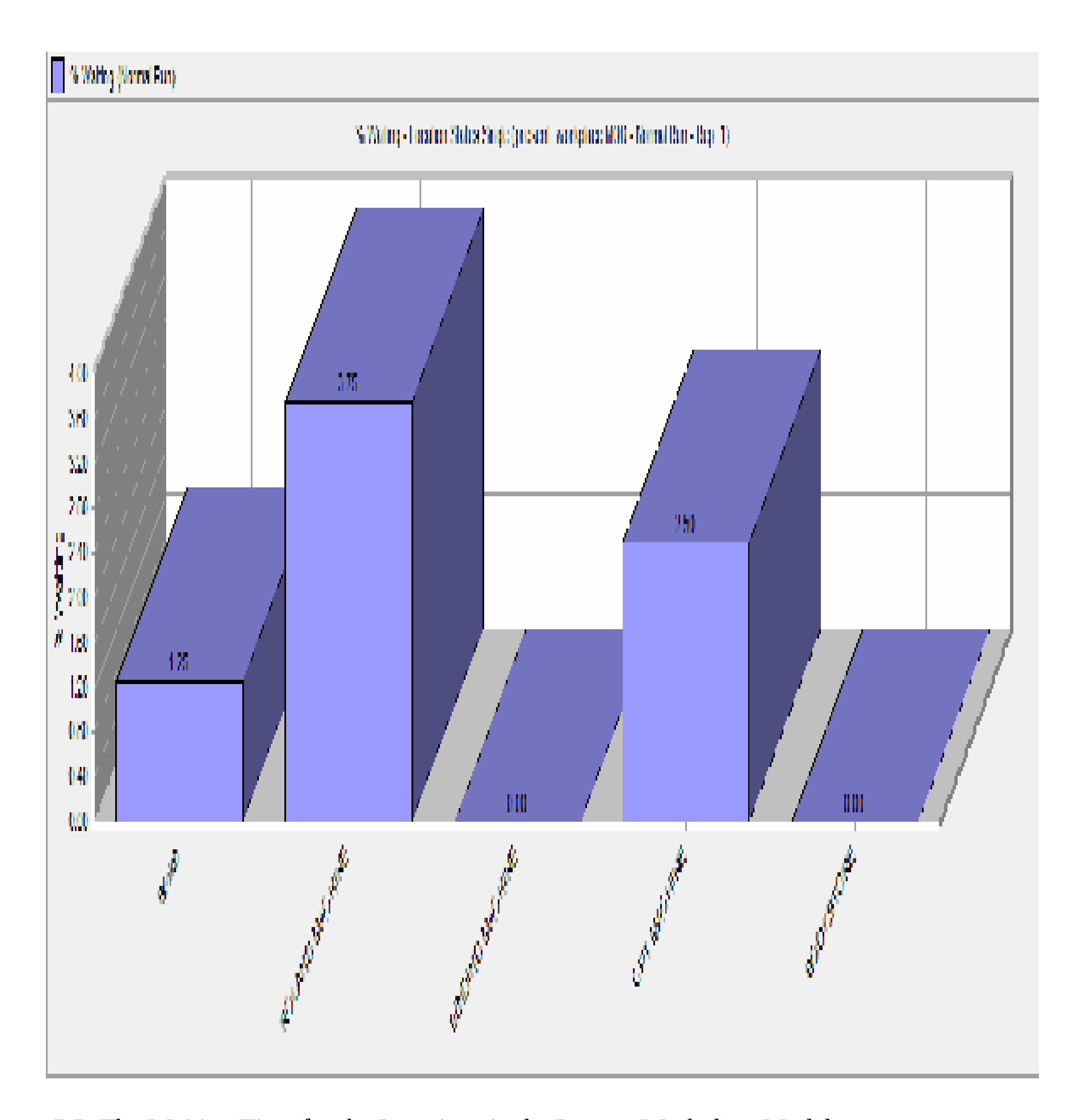
Table 5.2: The Utilization of the Location in the Model of Redesigned Workplace.

Locations	Percent %
Brake	16.00
Roland Machine	8.33
Bindind Machine	7.92
CPT Machine	8.86

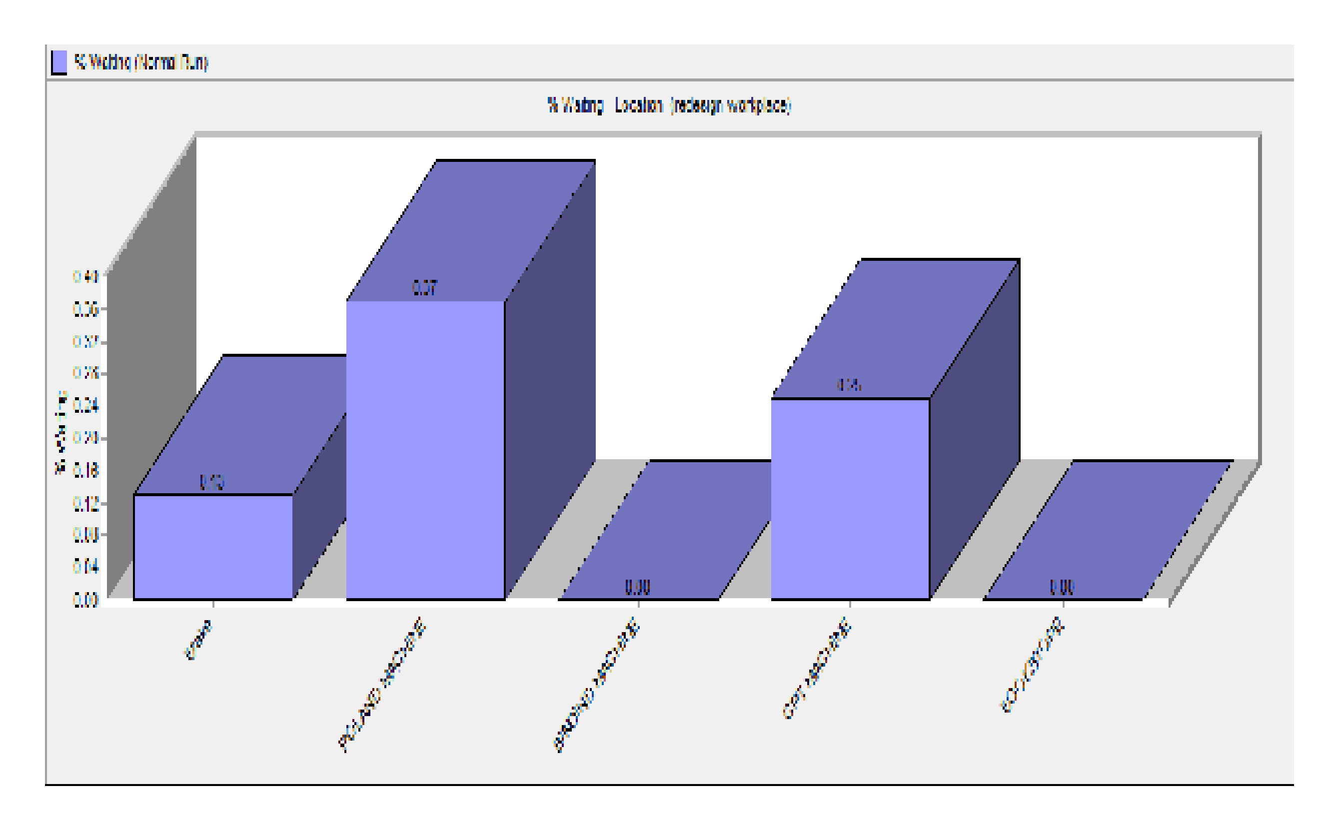
From the figures, utilization of the location in the redesigned workplace model shows better performance than the present workplace model for example the Break machine utilization was 16% in the present workplace and increased to 40.21% in the modified model.

There is usually a direct relationship between time and money. If the planned timescale is exceeded, the original cost estimates are almost certain to be overspent.

Figures 5-4 and 5-5, Table 5.3 and 5.4 illustrate the waiting time of the location in the two models.



Figures 5.5: The Waiting Time for the Locations in the Present Workplace Model



Figures 5.6: The Waiting Time for the Locations in the Redesigned Workplace Model.

Table 5.3: The Waiting Time for the Locations in the present workplace model

Locations	Percent %
Brake	1.25
Roland Machine	3.75
Bindind Machine	0.00
CPT Machine	2.50

Table 5.4: The Waiting Time for the Locations in the Redesigned Workplace Model

Locations	Percent%
Brake	0.13
Roland Machine	0.37
Bindind Machine	0.00
CPT Machine	0.25

From the Figures, the waiting time of the location in the redesigned workplace model shows better performance than the present workplace model. The

machines and departments in the present workplace wasted the time in waiting state, this cost more and decreased the performance of the machines and departments, for example Roland machines was wasted 3.75% of time in the present model compared to 0.37% in the redesigned model.

Another simulation element has been taken and studied in addition to the location state is the entity state. The following section gives the results of the entity state in the both models (present and redesigned workplace). Figures 5.7 and 5.8 show the in operation percent for the entity.

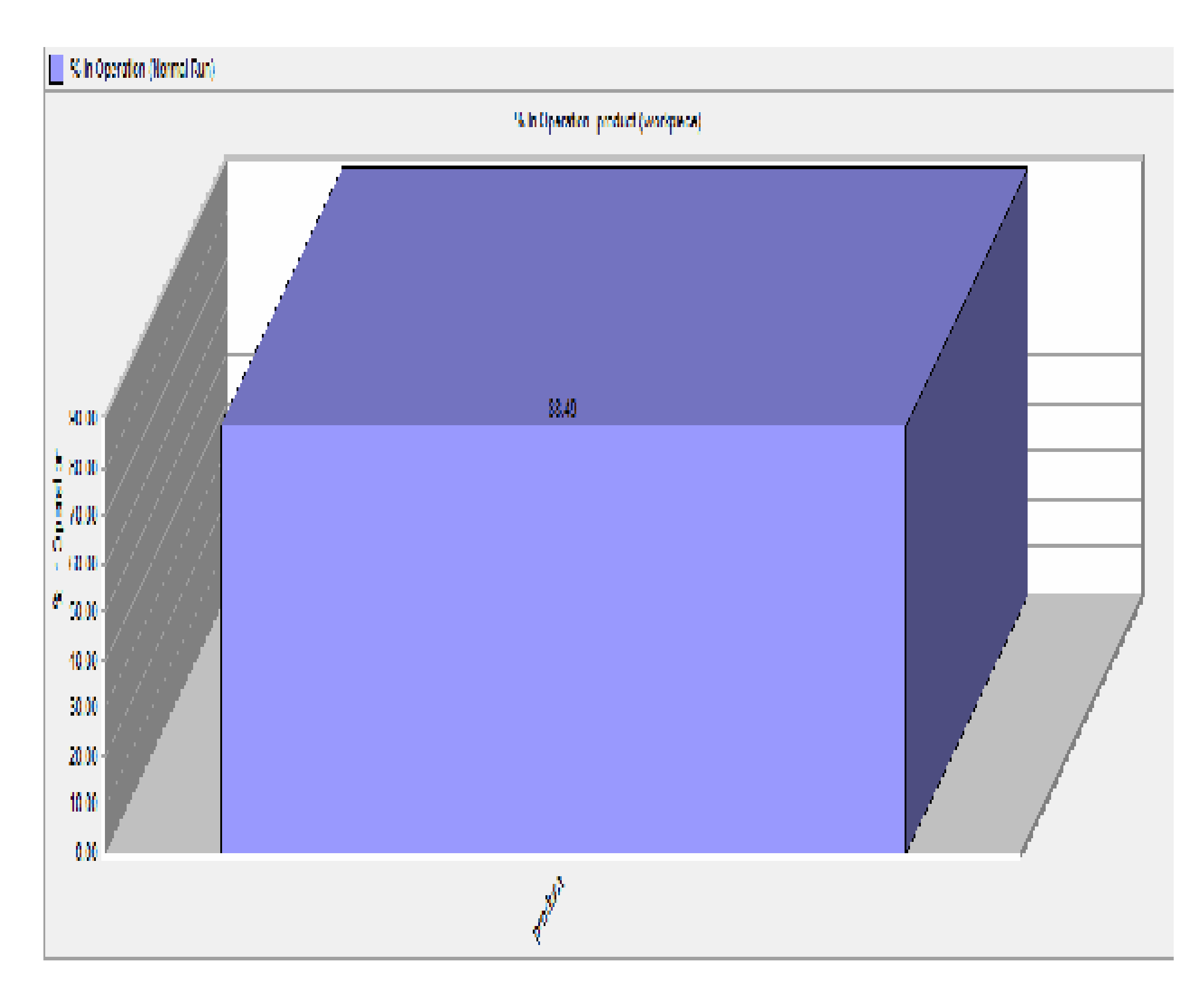


Figure 5.7: The In Operation Percent for the Entity in Present Workplace Model.

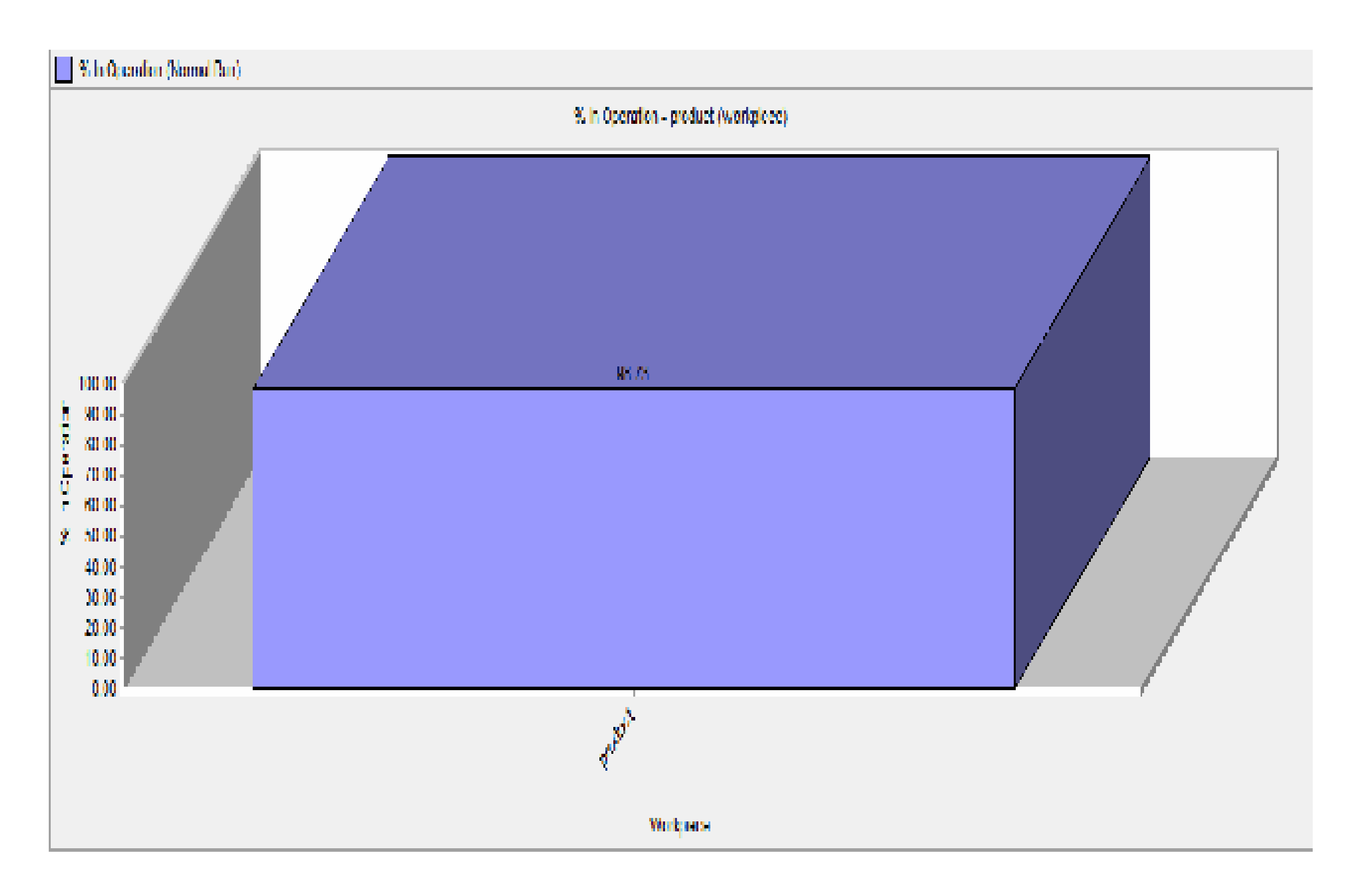


Figure 5.8: The In Operation Percent for the Entity in Redesigned Workplace Model.

The Figures show 10.24% difference between the two models. This ratio affect on the productivity and the efficiency. Hence the product spent 98.73% from the total time in operation state compared to 88.49%. This explains the main goal of the enhancement that the new design contributed to time saving and increased the efficiency.

Most time of the workflow cycle time wasted in materials-handling transferring between the machines and the departments. Figure 5.9 shows the percent of in move logic for the product according to the total time of the workflow in the present workplace, and for comparison, Figure 5.10 gives the redesigned percent.

It is worth mentioning here, the resource (worker) status, where 7.77% is the in use time percent for the worker in the present workplace compared to 0.77% for the redesigned model, which mean the redesigned model not only increasing the productivity but also managing time for the workers. Figures 5.11and 5.12 illustrate the in use time for the resource.

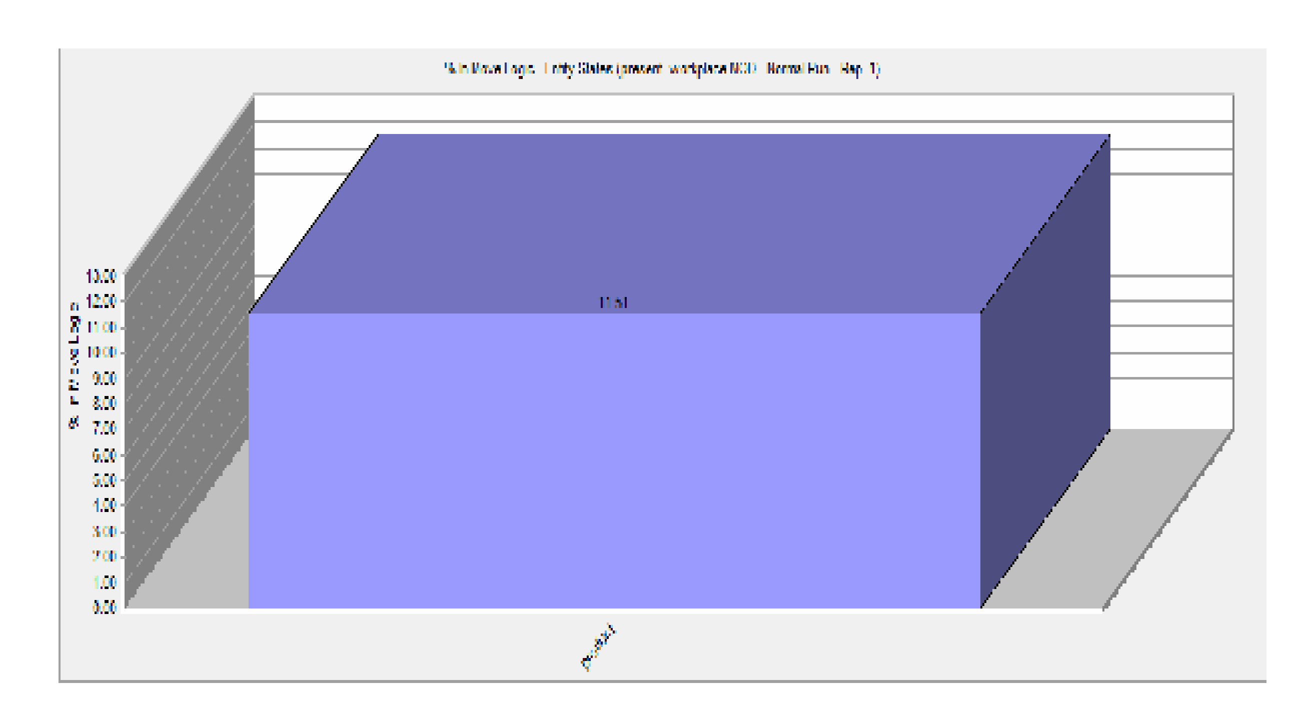


Figure 5.9: The In Move Percent for the Entity in Present Workplace Model.

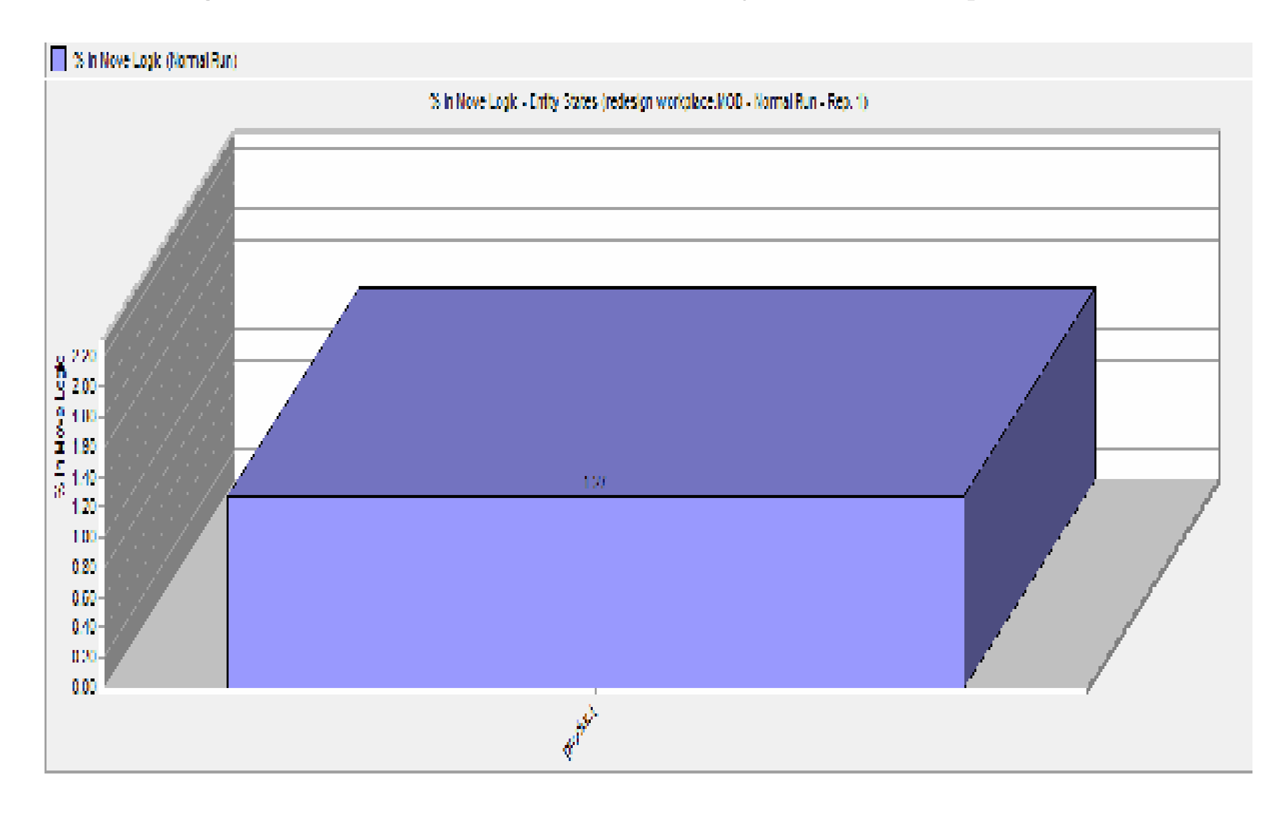


Figure 5.10: The In Move Percent for the Entity in Redesigned Workplace Model.

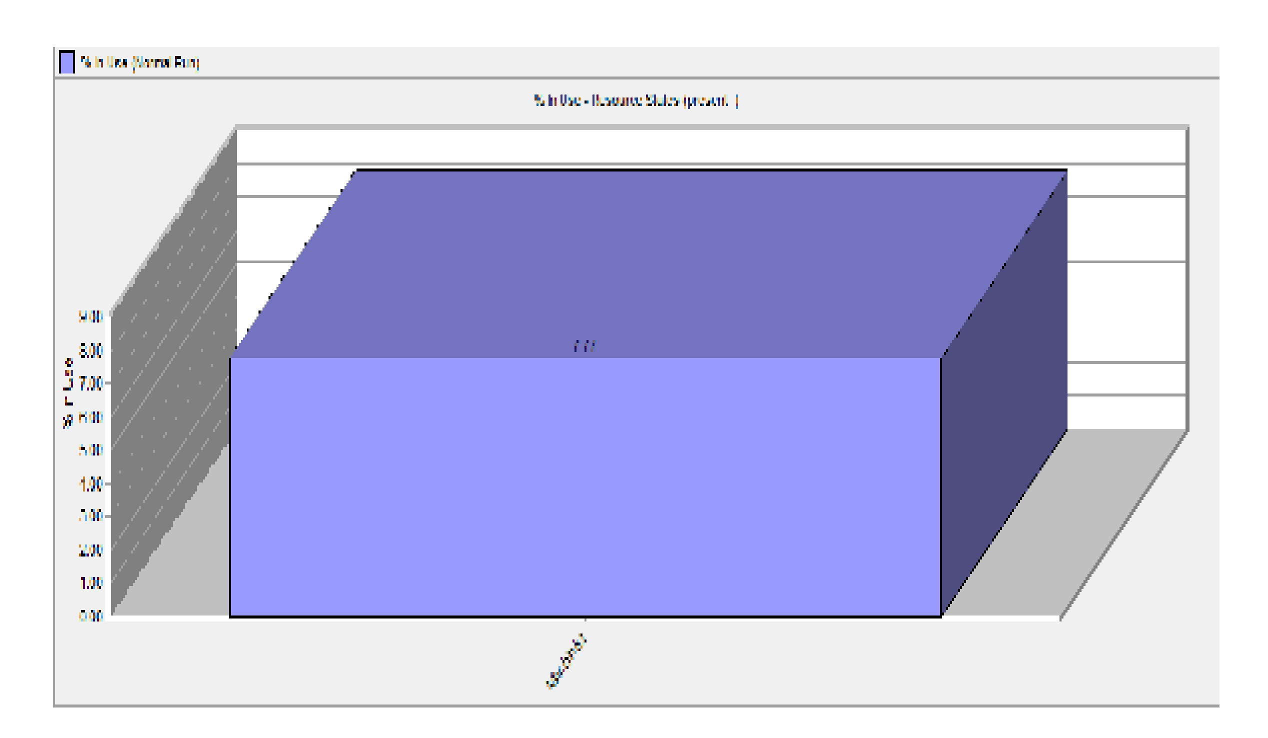


Figure 5.11: The In Use Percent for the Resource in Present Workplace Model.

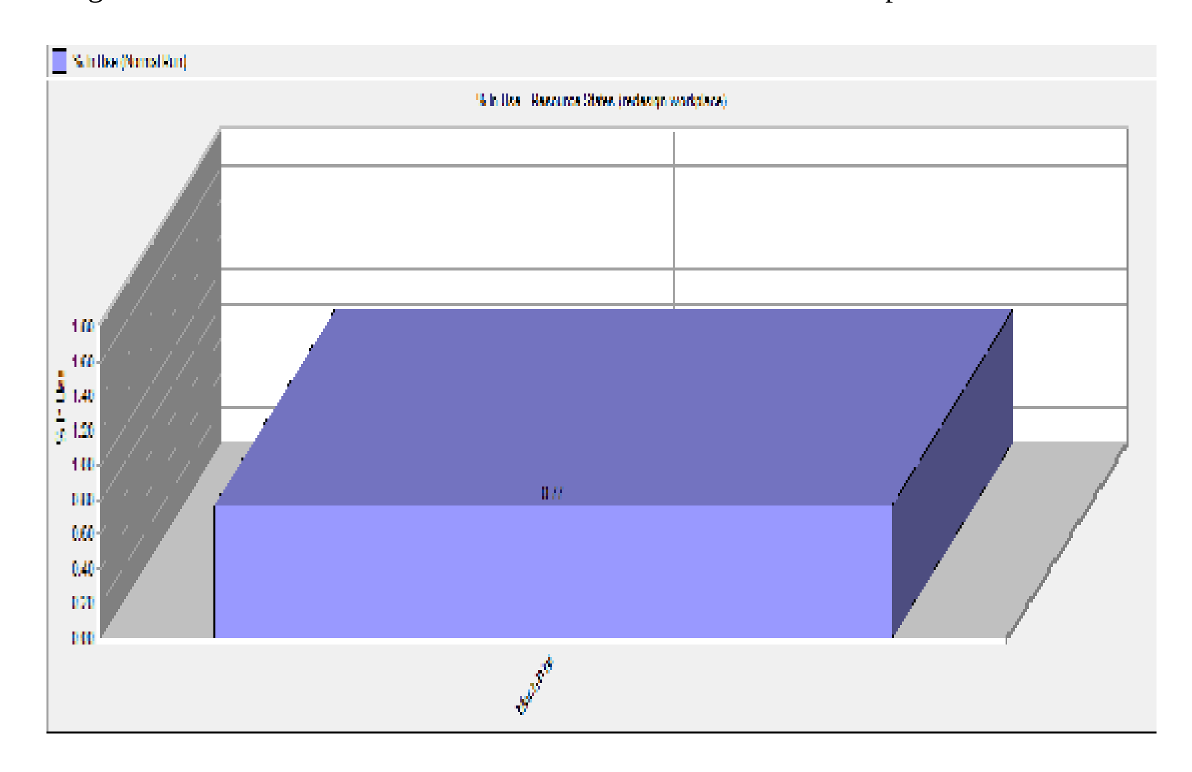


Figure 5.12: The In Use Percent for the Resource in Redesigned Workplace Model.

The result demonstrates the utilization performs well when the machines and departments are well located. It reduced the handover delay time and packet drop probability, cost and effort by employees.

Facilities layout problems deal with the selection of the most effective arrangement of physical facilities to satisfy multiple objectives, including material handling efficiency, floor space utilization, layout flexibility, safety, noise, esthetics, ease of supervision, expansion, and personnel utilization.

As a result, an efficient rate of production has risen significantly in the new design model.

In conclusion, rearranging layout decreased distance and time consumption in flow of material and accident which finally leads to an increase in productivity.

5.2 Mu'tah University Workshops Case Study

An extensive assessment was performed for the effective facility planning at the workplace. The results have shown that the existing workplace has not been designed and constructed to be workshop from the beginning. The construction was to Engineering College and later expanded and modified.

According to the limited area, the workshop elements and environment were unsuitable for the employees. This section deals with the description of the main workplace elements for the workshop including, safety, workplace area, and temperatures.

Most of the employers are complaining from upper and lower respiratory tract diseases, such as allergic bronchitis, bronchial asthma, allergic sinusitis and dermatological diseases such as contact dermatitis, urticaria and burns, also allergic conjunctivitis and chemical burns. The employees complaining of at least two of these diseases percent is 100%.

As a result of poor environment workplace such as a bad air circulation, the absence of van air condition, local ventilation, and the shortage of the safety equipment and the PPE (Head Protection, Ear Protection, Ear Muffs, Respiratory Protection and Hand Protection) will minimize the probability of accident. This may be the reason that about 90% of the employees in the workshop did not give attention to the safety equipment.

100% of the employees had accident at work, 80% was due to the located machines very close to each other, the limited workplace space, and the disagreement arrangement in the workflow.

The results related to the temperatures in the workplace, were found lack of air conditioning system. This was clearly from the temperature measurements collected throughout the study particularly in summer time. It was clear that the staff are suffering from high temperature in summer specially that these temperatures reached up outside temperatures particularly one of the workshops

has an outside area uncovered for this and as improvement the new design support the idea.

Fire is the most common serious hazard that one faces in any workplace. A fire extinguisher is an active fire protection device used to control small fires, often in emergency situations.

Figure 5.13, indicates that the availability of fire extinguisher in the Workshops is 0%, which means that it is very difficult to deal with any major fire that may happen at the workshop. It seems that most extinguishers are without serious maintains and most people are not well trained enough to deal with extinguishers, which lead to humanitarian and financial loss.

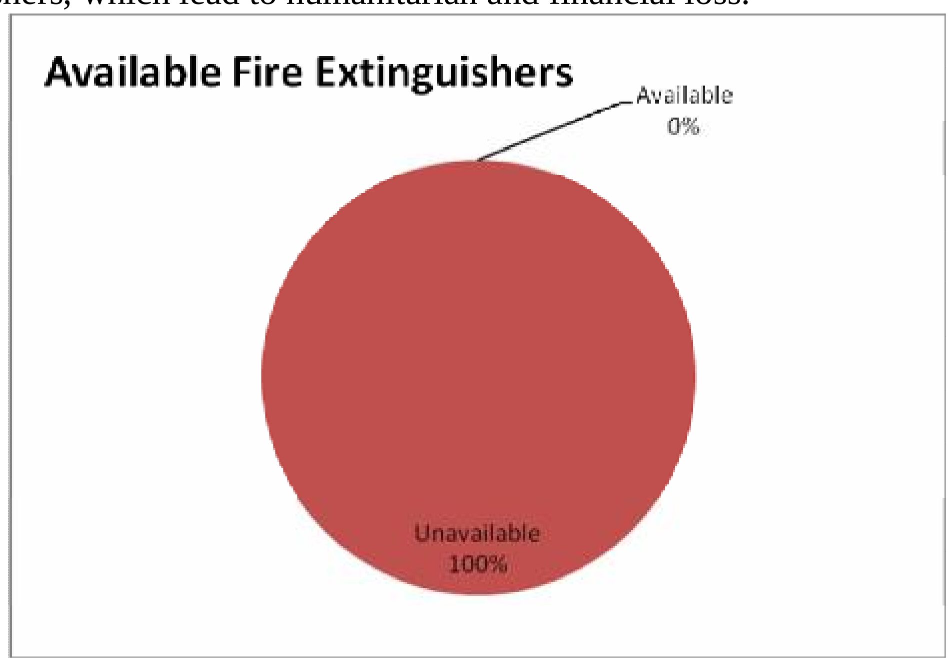
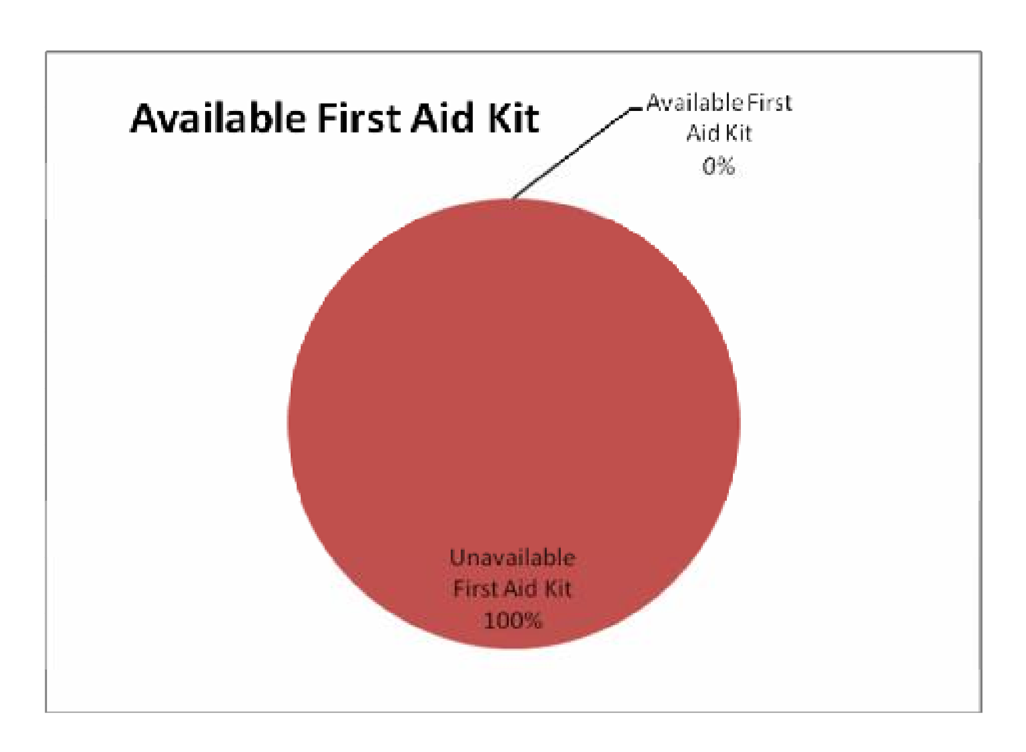


Figure 5.13: The Availability of Fire Extinguisher in the Workshops



5.14: The Availability of First Aid Kit in the Workshops Figure

A first aid kit should be available in case of injuries and any illnesses cases likely to occur at the workplace, the study showed that the first aid kit is not available in the workshops.

Figures 5.15, 5.16, and 5.17 show the workplace area compared with the standards in carpentry, upholstery and welding workshops. However Figures 5. 18, 5.19, and 5.20 illustrate the windows coverage area compared with standards.

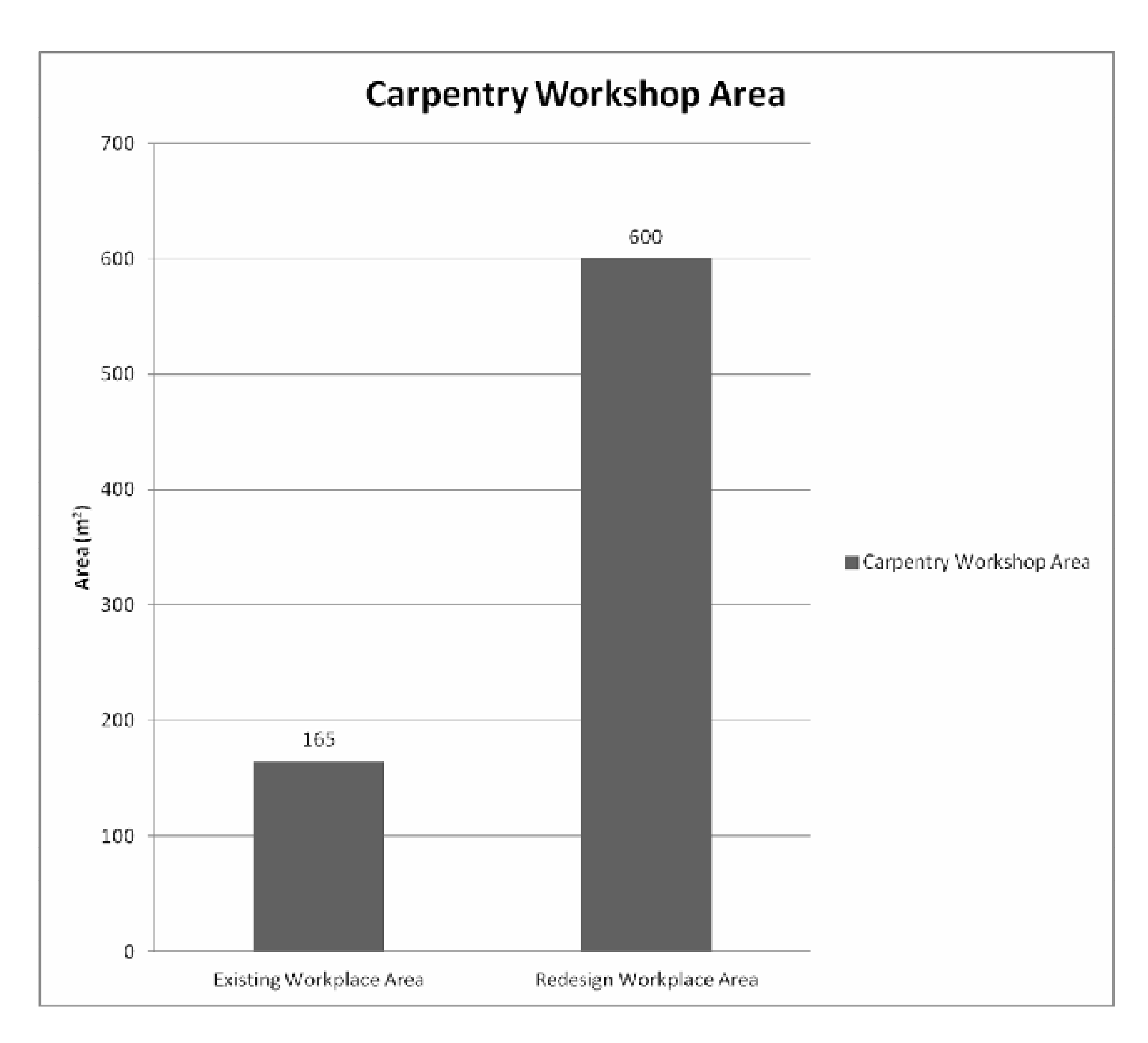


Figure 5.15: Comparison between the Existing Carpentry Workshop Area and the Redesigned.

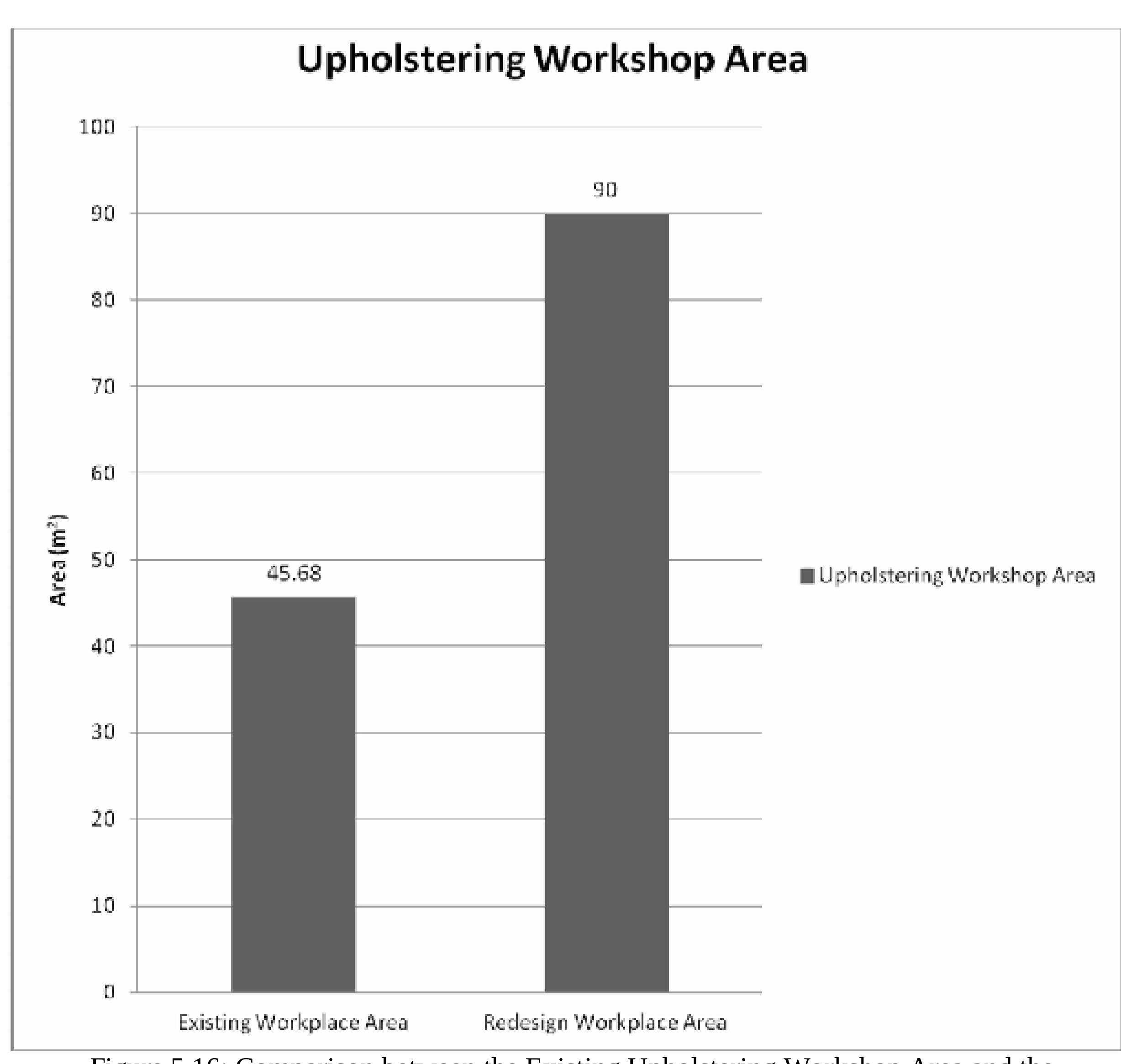


Figure 5.16: Comparison between the Existing Upholstering Workshop Area and the Redesigned.

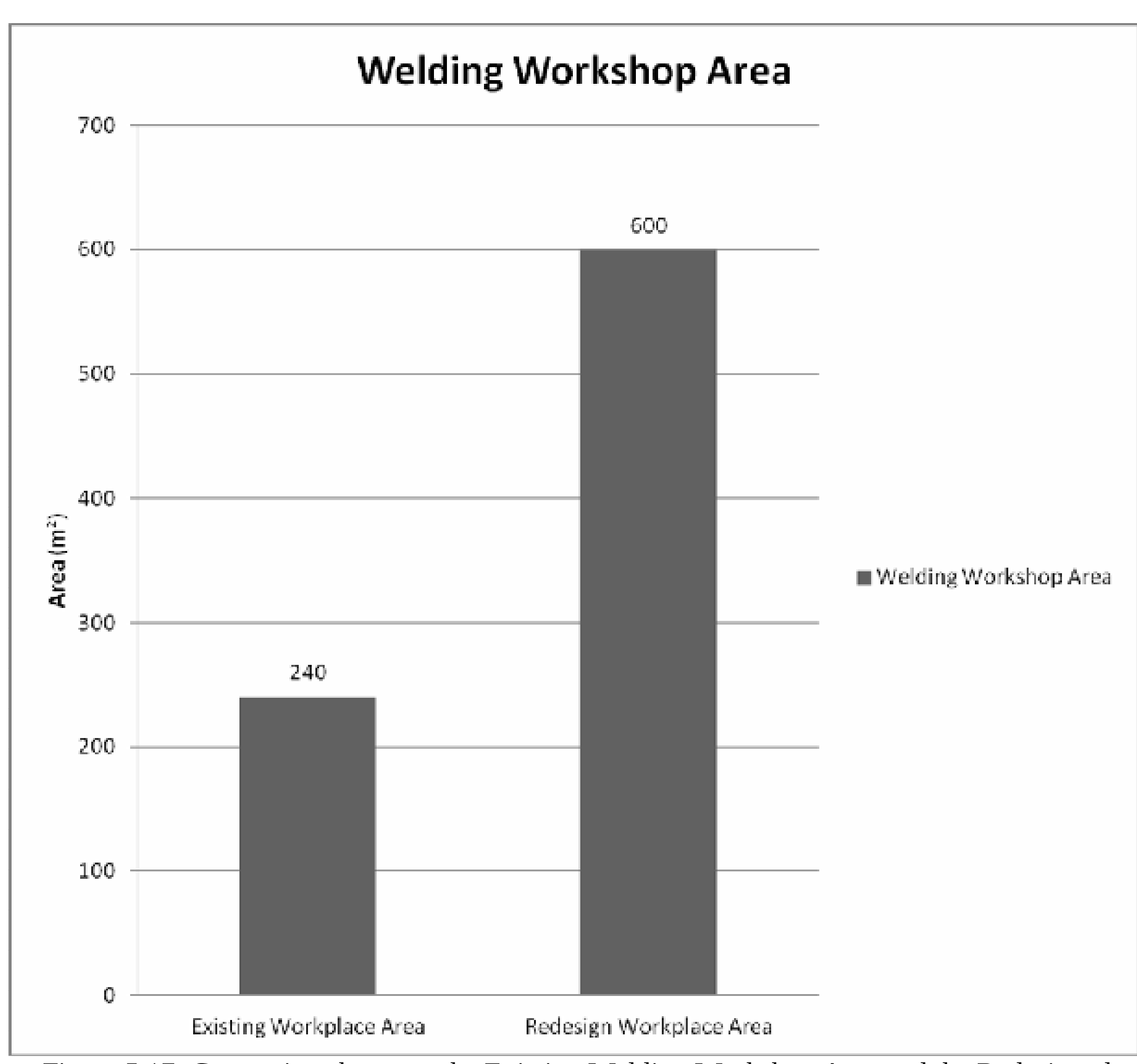


Figure 5.17: Comparison between the Existing Welding Workshop Area and the Redesigned.

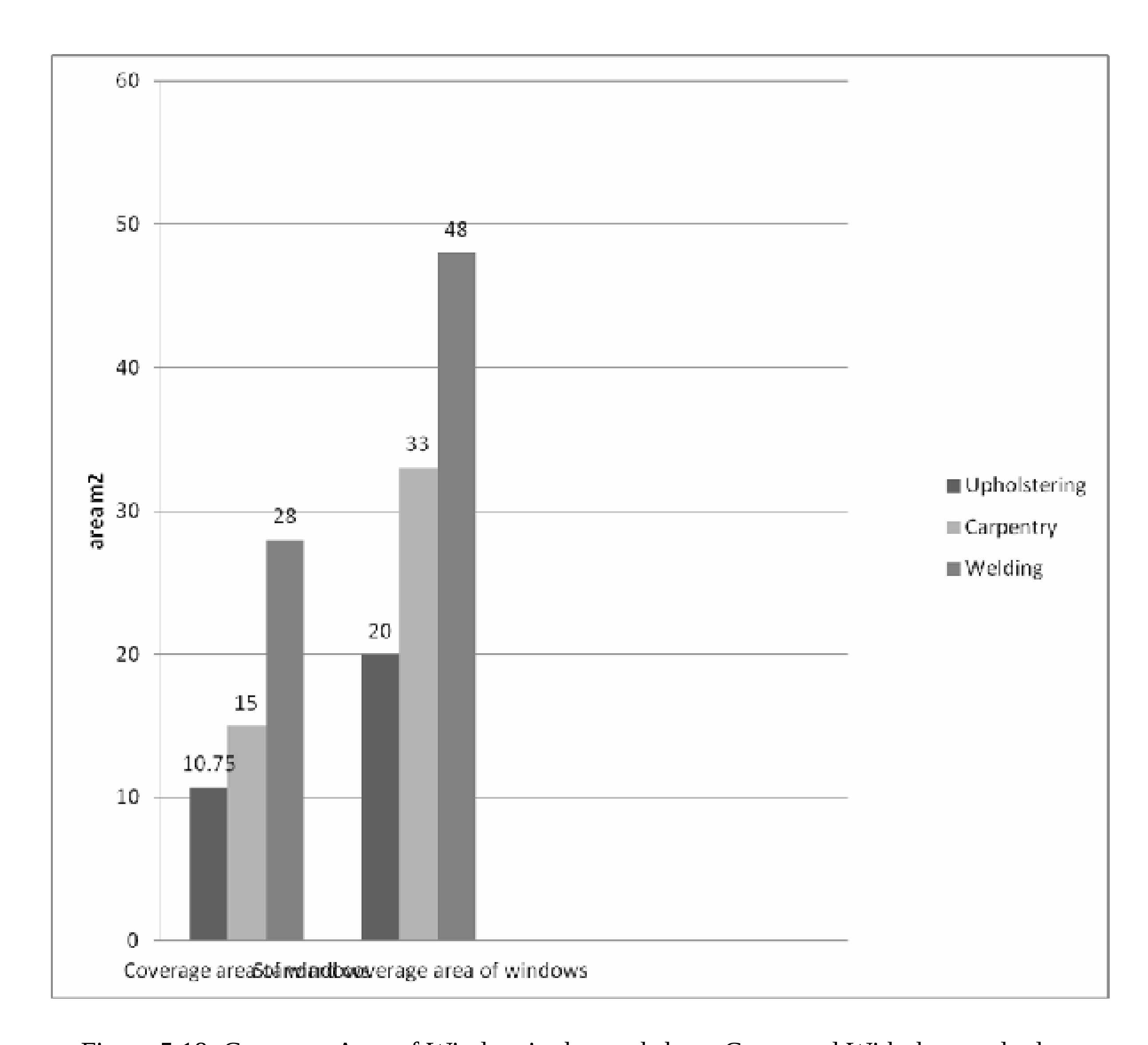


Figure 5.18: Coverage Area of Window in the workshops Compared With the standards.

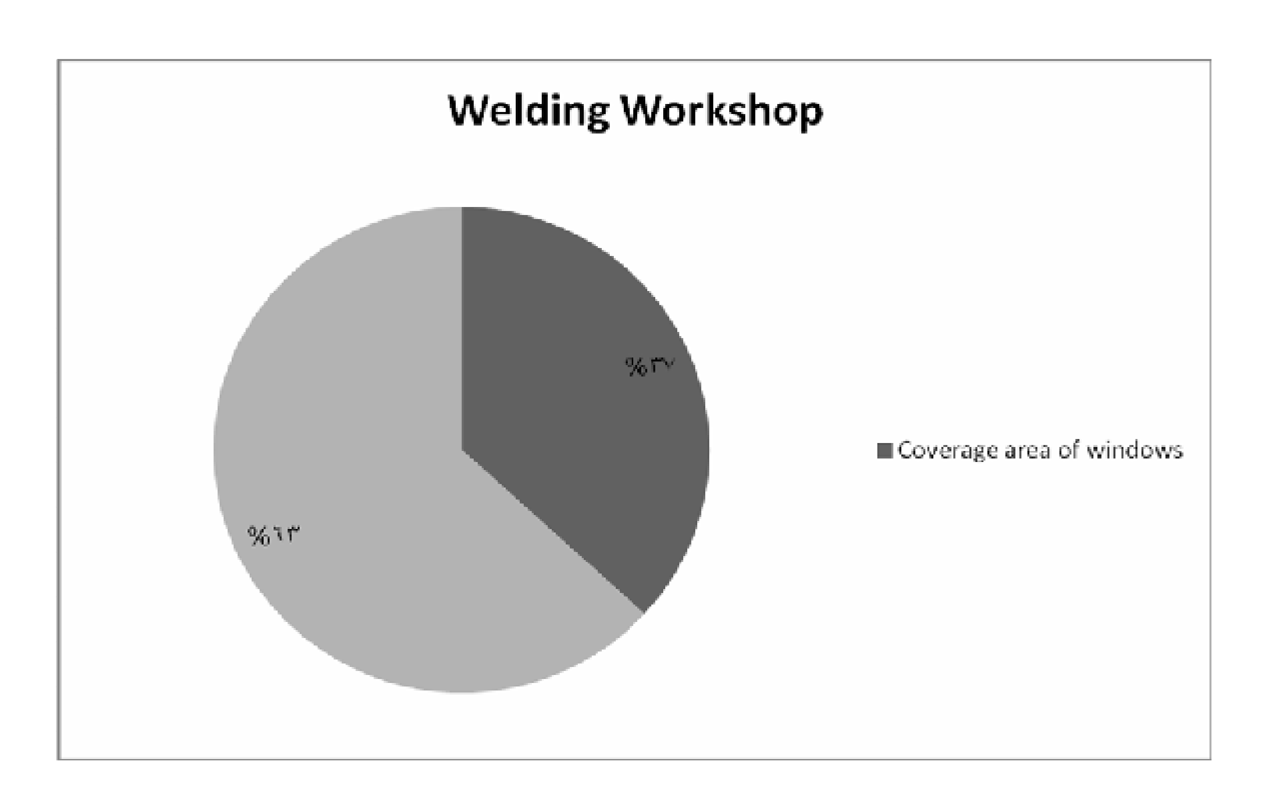


Figure 5.19: Coverage Area of Window in Welding Workshop.

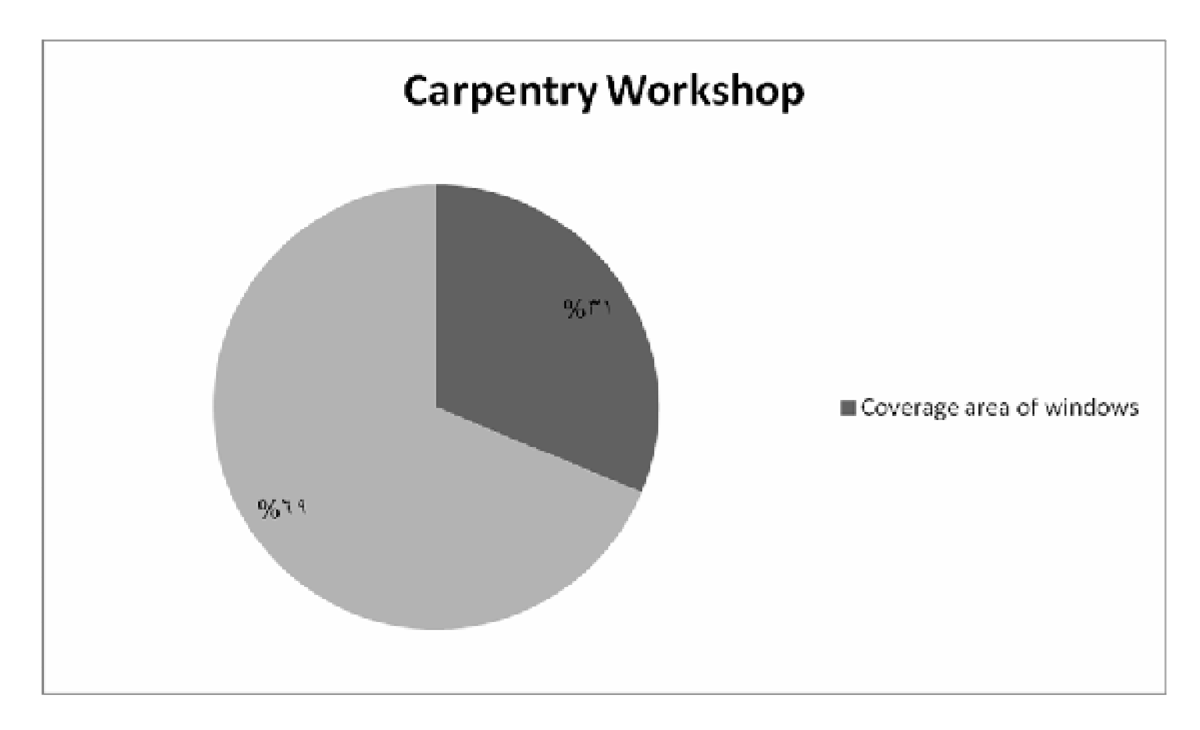


Figure 5.20: Coverage Area of Window in Carpentry Workshop

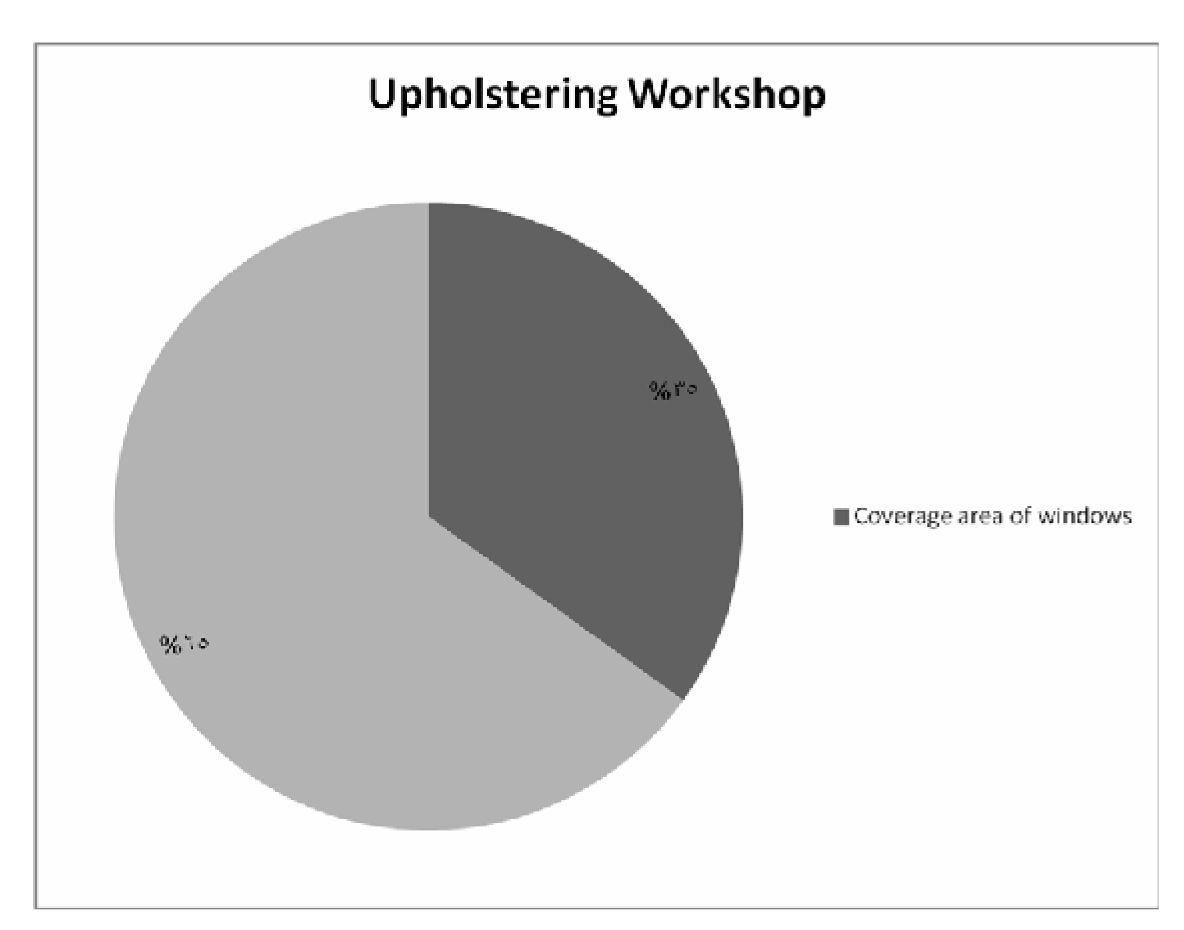
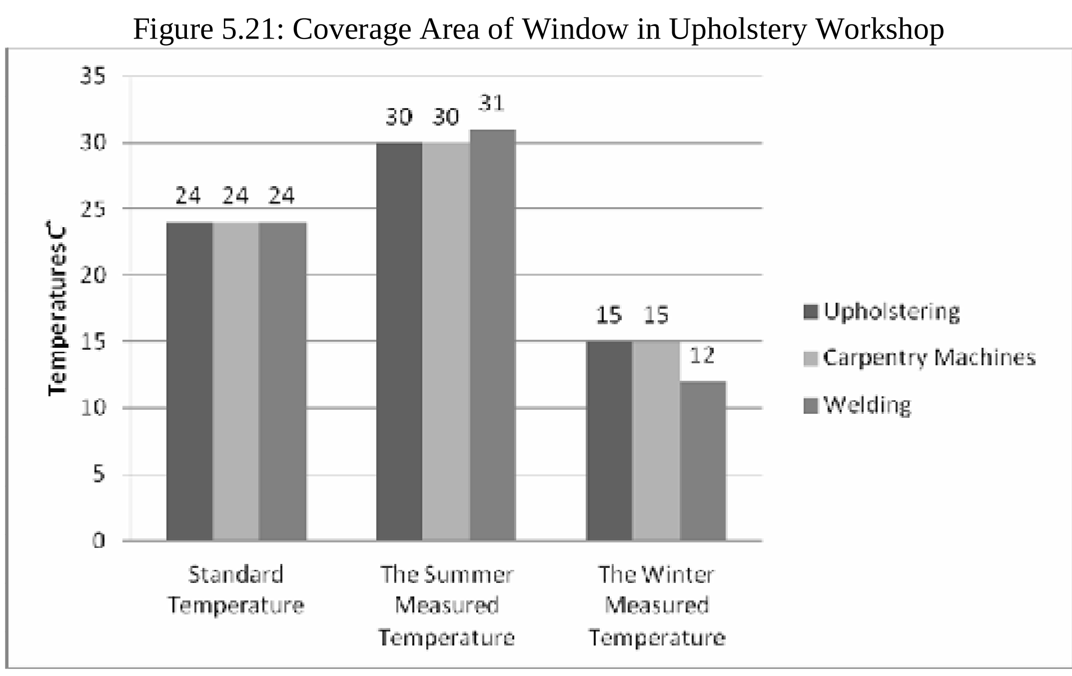


Figure 5.21: Coverage Area of Window in Upholstery Workshop



5.22: Temperatures in the Workshops Figure

The Workplace (Health, Safety and Welfare Regulations 1992) lay down particular requirements for most aspects of the working environment. Regulation 7 of these Regulations deals specifically with the temperature in indoor workplaces and states that: During working hours, the temperature in all workplaces inside buildings should be reasonable. The temperature in workrooms should be normally at least 24 degrees Celsius. However, it is clearly that the fluctuation of the temperatures measured in the workplace during the seasons according to it is so important that all reasonable steps should be taken to achieve a reasonably comfortable temperature such as installed cooling system.

5.3 Conclusions

The following conclusions can be obtained from the analysis of the redesigned cases of study:

5.3.1 Workshops at Mu'tah University:

1) The difference between the workplace elements of the international standard and the present workplace is very clear and obviously will be reflected to employee activities, health, productivity, and product quality.
2) The redesigned workplaces show that some work places differ by about 100% in comparison with present workplace or with the international standards.
3) The present building shows excessive levels of noises, air contamination, heat, moisture and smells.

5.3.2 Al-Doustour Newspaper Industry Workplace:

1) Relocating the CTP Department according to model, to become closer to the other related departments and machines. This would contribute to time saving and increase the efficiency of handling the plates from the CPT department to the ROLAND machines.
2) Placing all departments within the same floor contribute to the reduction in electricity consumption. The staff do not need to use elevators to transfer the work between the different floors i.e. avoid the vertical movements to reduce the time and the effort.

5.3.3 The Role of Engineering Management in Improving Workplace Design:

1) The purpose of analyzing such demands related to the building is to alert the facility planner on the effects that may affect the building and its facility.
2) CAD layout plays a great role in evaluating plant layout before actual building take places to avoid extra costs in the future.

5.4 Recommendations

A number of recommendations have emerged from this work. Some of them are related to the main scope of the research while others are general. However, the following is a summary of these recommendations:

1) Although the present work has covered only two case studies, the main however findings identified are expected to be the same at many other workplaces, therefore it is highly recommended that awareness raising events and activities to be organized to highlight the importance of the utilization similar techniques and approaches to encourage firms/industries to design and redesign their workplaces not only to meet the international standards but to increase their productivity and efficiency. Chamber of Industry in Jordan and the Jordan Engineers Association may play a significant role in this regard.
2) It is envisaged that the concept of the present research and the methodology followed could be applied to assess the office work environment including office layouts on the work effectiveness at Mu'tah University. Of particular importance in this regard is the assessment of weather office spaces are being used effectively. Such assessment and any subsequent enhancement and improvements would certainly lead to effective performance of employees and operations.
3) It would also be recommended to examine the impact of workplace designs on individual performance but with a further focus. This could be done on the same case studies or propose new ones.
4) A supplementary work could be conducted to study the relationships between workplace design elements and organizational work performance and individual performance.
5) Health potential risk of existing designs at the workplaces examined in this research could also be a scope/objective of future work. Mitigating such potential risk by applying Computer Aided Workplace Design models and software should also be considered along.
6) The present research would recommend (a general recommendation) regarding the promotion of friendly workplace design by on applying appropriate the necessary guidelines or even legislations that would encourage industries/firms to invest in "re-designing" their workplaces in manner that contribute to energy saving, quality improvement, waste minimization, ..etc. Integrating "workplace design” as an element and a criteria for Environmental Management Standard e.g. ISO 14000 / ISO 14001 is a suggestion in this regard.

7) Finally, given that, Jordan is experiencing a serious challenges with respect to energy resources, the concerned authorities have to encourage all industries and firms to reconsider their workplaces designs in order to minimize energy consumption (energy is one of the main elements usually considered in the assessment of workplace designed) that might result from inappropriate layouts of these workplaces.

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